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Assessment of the Gulf of Maine Cod Stock for 1994

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R. K. Mayo

Report of the 19th SAW

NOAA/National Marine Fisheries Service
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CRD 95-09	Report of the 19th Stock Assessment Workshop (19th SAW) The Plenary

ABSTRACT

The status of the Gulf of Maine cod (*Gadus morhua*) stock is reviewed and estimates of 1993 fishing mortality and 1994 stock size and spawning stock biomass are presented. Precision of the 1993 fishing mortality and spawning stock biomass estimates, and a retrospective analysis of the performance of the VPA for Gulf of Maine cod are also provided. Short-term projections of 1995 landings and resulting 1996 spawning stock biomass at various levels of 1995 fishing mortality, and medium-term forecasts of landings and spawning stock biomass are also given. The 1994 assessment was based on several diverse sources of information including: USA landings at age estimates, Northeast Fisheries Science Center (NEFSC) and Massachusetts Division of Marine Fisheries (DMF) spring and autumn research vessel survey data, and standardized USA commercial fishing effort data.

Total landings of Gulf of Maine cod declined in 1993 to 8,300 metric tons (mt) from a recent high of 17,800 mt in 1991, a decrease of about 53%, and one of the lowest annual totals since the mid-1970s. Commercial landings per unit of standardized effort declined steadily between 1982 and 1987, but increased abruptly in 1990 and remained high in 1991. Commercial LPUE declined sharply in 1992 and remained low in 1993. Fishery-independent spring and autumn bottom trawl surveys conducted by the Northeast Fisheries Science Center have also documented a steady decline in total stock biomass since the 1960s; the largest decreases occurred during the 1980s. The 1993 and 1994 indices suggest that the Gulf of Maine cod stock is at a record-low biomass level. Except for the 1986 and 1987 year classes, recent recruitment indices of age 1 and 2 cod from the NEFSC autumn surveys have been well below levels observed prior to the 1980s.

Spawning stock biomass has declined from over 26,000 mt in 1989 to record low levels of 9,400 mt in 1993 and 8,100 mt in 1994. At the present level of exploitation and, given the probable level of recruitment in the near term, the decline in spawning stock biomass is expected to continue. Fishing mortality has remained at about 1.0 since 1983, resulting in an exploitation rate of about 58%. If this level of exploitation continues, landings are expected to decline to less than 7,000 mt in 1995 and spawning stock biomass is projected to decline to about 6,500 mt in 1996.

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INTRODUCTION

Atlantic cod (*Gadus morhua*) in the Gulf of Maine region have been commercially exploited since the 17th century, and reliable landings statistics are available since 1893. Historically, the Gulf of Maine fishery can be separated into four periods (Figure 1): (1) an early era from 1893-1915 in which record-high landings (> 17,000 mt) in 1895 and 1906 were followed by about 10 years of sharply-reduced catches; (2) a later period from 1916-1940 in which annual landings were relatively stable, fluctuating between 5,000 - 11,500 mt and averaging 8,300 mt per year; (3) a period from 1941-1963 when landings sharply increased (1945: 14,500 mt) and then rapidly decreased, reaching a record-low of 2,600 mt in 1957; and (4) the most recent period from 1964 onward during which Gulf of Maine landings have generally increased. Total landings doubled between 1964 and 1968, doubled again between 1968 and 1977, and averaged 12,200 mt per year during 1976-1985 (Table 1). Although Gulf of Maine landings declined between 1984 and 1987, landings subsequently increased, reaching 17,800 mt in 1991, the highest level since the early 1900s. Total landings declined sharply in 1992 to 10,892 mt, and decreased further in 1993 to 8,287 mt.

This report presents an updated and revised analytical assessment of the Gulf of Maine cod stock (NAFO Division 5Y) for the period 1982-1993 based on analyses of commercial and research vessel survey data through 1993. An initial analytical assessment of this stock was presented at the Seventh NEFC Stock Assessment Workshop in November 1988 (NEFC 1989) and subsequent revisions were presented at the Twelfth and Fifteenth Northeast Regional Stock Assessment Workshops in June, 1991 and December, 1992 (NEFSC 1991, 1993; Mayo *et al.* 1993). Recreational cod catches have not been included in any of the analyses due to limited data on recreational cod landings by stock (Serchuk and Wigley 1990).

THE FISHERY

Commercial Fishery Landings - Total commercial landings in 1993 were 8,287 mt, 24% less than in 1992 and 53% less than in 1991 (Table 1). Since 1977, the USA fishery has accounted for all of the commercial catch. Canadian landings reported as Gulf of Maine catch during 1977-1990 are believed by Canadian scientists to be misreported catches from the Scotian Shelf stock (Campana and Simon 1985; Campana and Hamel 1990). Although otter trawl catches accounted for most of the landings in 1993 (59% by weight), the quantity taken gill nets increased to 38% from a low of 23% in 1991; the 1993 gill net catches were at a percentage comparable to the 1987-1989 period (Table 2).

Recreational Fishery - Estimates of the recreational cod catch were derived from the Marine Recreational Fishery Statistics Survey (MRFSS) conducted since 1979. The Gulf of Maine cod catch was estimated on the assumption that the catches of cod recorded by the intercept survey were removed from the ocean in statistical areas adjacent to the state or county of landing. Further information on the details of the allocation scheme and sampling intensity are given in NEFSC (1992). Recreational cod catches in the Gulf of Maine region were 2,667 mt in 1993 (Table 3). The estimated catch from the Gulf of Maine cod stock declined from over 5,000 mt in 1980 and 1981 to 2,400 mt in 1986, increased to 4,200 mt in 1989 and have fluctuated between 1,000 and 3,000 mt since 1990.

Sampling Intensity - A summary of USA length frequency and age sampling of Gulf of Maine cod landings during 1982-1993 is presented in Table 4. USA length frequency sampling averaged one sample per 155-200 mt landed during 1983-1987 but the sampling intensity has declined in recent years (1990: 1 sample per 387 mt; 1993: 1 sample per 360 mt). Only 23 samples were taken in 1993. Virtually all of the USA samples have been taken from otter trawl landings but sampling is stratified by market category (scrod, market, and large). Of the 23 samples collected in 1993, 10 were scrod samples (43%), 8 were market (35%), and 5 were large (22%). Compared with the 1993 market category landings distribution (by weight - scrod: 21%; market: 44%; large: 32%) (Table 5), 'scrod cod' were oversampled and 'market' and 'large cod' were undersampled.

Age Composition - Age composition of landings during 1982-1993 was estimated, by market category, from monthly length frequency and age samples, pooled by calendar quarter. Quarterly mean weights, by market category, were obtained by applying the NEFSC research vessel survey cod length-weight equation ($\ln \text{Weight}_{(kg,live)} = -11.7231 + 3.0521 \ln \text{Length}_{(cm)}$) to the quarterly market category sample length frequencies. Mean weight values were then divided into quarterly market category landings to derive estimated numbers landed by quarter, by market category. Quarterly age/length keys were then applied to the quarterly market category numbers at length distributions to provide numbers at age. These values were summed over market categories and quarters to derive the annual catch-at-age matrix (Table 6).

Gulf of Maine cod landings were dominated by fish from the 1987 year class in 1992 but, by 1993, fish from the 1990 year class accounted for the greatest proportion of the total number landed (Table 6). In terms of weight, the 1993 landings were equally distributed between the 1987 and 1990 year classes. In 1993, these two year classes accounted for approximately 70% of the total number and weight landed. Although traditionally low in terms of their contribution to the total landings, age 10 and 11+ fish were completely absent in 1993, and numbers of age 8 and 9 fish were unusually low. Although this pattern may be partly a result of the poor sampling of 'large' category cod in 1993, a trend towards fewer older fish in the landings has been apparent since 1991.

Mean Weights at Age - Mean weights at-age in the catch for ages 1-11+ during 1982-1993 are given in Table 6 and, based on landings patterns, are considered mid-year values. Apart from 1990, only slight variations are apparent among years with no consistent trends evident. In 1990, mean weights at age for age groups 2-4 were the lowest in the nine-year time series while mean weights for age groups 6 and 7 were the highest. These changes, however, may be artifacts of the reduced sampling intensity of the landings in 1990 as indicated by the increase in mean weights at ages 2 and 4 in 1991. In 1993, mean weights at ages 8 and 9 were the highest in the series, but these anomalies are likely the result of poor sampling. Catch at age and recalculated mean weights at age for the 7+ group which are used in the VPA are given in Table 7. Mean weights at age for calculating stock biomass at the beginning of the year are provided in Table 8. These values were derived from the catch mean weight at age data (Table 6) using the procedures described by Rivard (1980).

STOCK ABUNDANCE and BIOMASS INDICES

Commercial Catch Rates - USA commercial LPUE indices (landings per unit effort, expressed in metric tons landed per day fished) were calculated, by tonnage class (Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT), from otter trawl trips landing cod from the Gulf of Maine (Division 5Y). Indices were derived based on all trips landing cod, and for "directed" trips in which cod comprised 50% or more of the total trip catch by weight (Tables 9 and 10). "Directed trips" have generally accounted for less than 45% (and as low as 14%) of USA Gulf of Maine otter trawl landings of cod but after 1988 "directed trips" began to account for an increasing percentage of the total catch (Table 11). The fraction of the otter trawl catch taken on "directed trips" increased from 35% of the total in 1988 to 71% in 1991. The "directivity" of the otter trawl fishery declined in 1992 and 1993 to pre-1989 levels. The temporary increase in directivity, which peaked in 1991, is the likely result of the dominant influence of the unusually strong 1987 year class in the fishery. This trend is apparent within and among all vessel class categories.

Both total and directed USA LPUE indices have generally exhibited similar trends (Table 9, Figure 2). LPUE values increased during the late 1960s, declined during the early 1970s, sharply increased in 1974, and then stabilized during 1975-1983 at a relatively high level. After 1983, LPUE indices trended downward, reaching record-low levels in 1987. Both total and directed LPUE indices increased between 1988 and 1991; in 1991, the total LPUE index was the highest since 1977 (and among the highest in the time-series) while the directed index declined from the 1990 level. In 1992 and 1993, both indices declined and the total index reached a level close to the lowest on record in 1993. Between 1988 and 1991, the percentage of total trips qualifying as directed trips quadrupled (Table 11: 8% to 33%), but the proportion qualifying declined sharply by 1993 (14%).

Although the total number of cod trips has been generally declining relative to 1988, the number of directed trips increased 7-fold between 1987 and 1991 (Table 10: 300 trips in 1988 vs 2,147 trips in 1991). This suggests that the very high total LPUE index for 1990 and 1991 is rather inflated due to a marked change in fleet "directivity", particularly by Class 4 vessels. In 1988, 5% of Class 4 cod trips were "directed" while in 1991, 57% of Class 4 trips qualified as "directed" (Table 11). The number of "directed" trips declined markedly in 1992 and 1993, reflecting both a decline in overall effort and a decrease in the directivity of the fishery.

In terms of calculated effort (total landings/total USA LPUE index), total fishing effort reached a record-high level in 1987, declined from 1988 to 1990, and has since increased well above the 1990 level (Table 12). To the extent that the 1990 and 1991 total LPUE indices are 'inflated' (due to increased fleet directivity for cod), the calculated effort values for 1990 and 1991 are underestimated. Therefore, the total calculated effort on Gulf of Maine cod since 1984 appears to have remained at a consistently high level relative to the 1960s and 1970s.

Standardized fishing effort and LPUE were estimated for a sub-fleet by applying a five-factor (year, area, quarter, tonnage class and depth) General Linear Model (GLM) to log LPUE data derived for all interviewed otter trawl trips taking cod from 1982 through 1992 (Table 13). Details regarding data selection and preparation and model formulation are provided by Mayo *et al.* (1994). The model accounted for just under 25% of the total sum of squares, although all five factors were highly significant. For each year between 1982 and 1993 standardized effort in each area-quarter-tonnage class-depth category was estimated by multiplying the sum of the nominal effort for that cell by the product of the re-transformed GLM coefficients for each factor. The estimated standardized sub-fleet effort was then accumulated over all categories to provide annual estimates as given in Table 14. Total standardized effort was then calculated by raising the sub-fleet effort to account for all cod landings. Both series of USA effort estimates (Tables 12 and 14) show the same trends over time, ie., an increase during the 1980s with peak effort occurring in 1987 followed by a decline, with effort rather variable since 1991 (Figure 3). Both series also reveal a sharp decline in LPUE of about 50-60% between 1991 and 1993 (Tables 12 and 14; Figure 2).

Given the differences in the two methods used for computing fishing effort, it is not surprising that the two methods produce slightly different results. The GLM method accounts for spatial and seasonal effects, as well as tonnage class differences. The 'calculated effort' approach does not explicitly consider these factors and hence may be more sensitive to changes in fleet directivity. The increased directivity of the USA fishery during 1990 and 1991 probably inflates the 'all cod trips' USA LPUE indices in these years since a greater proportion of the total cod landings is represented by directed trips. Hence, the 'calculated effort' values for 1990 and 1991 should probably be considered as underestimates.

The 1982-1993 age composition of the landings corresponding to the effort sub-fleet was estimated and used with standardized effort estimates to calculate a LPUE at age index. Numbers landed at age were estimated by applying quarterly commercial age-length keys to quarterly commercial numbers landed at length by market category. The LPUE at age indices were derived by dividing the estimated numbers landed at age by corresponding 1982 through 1993 standardized fishing effort. Further details regarding data selection and preparation and estimation procedures are provided in Mayo *et al.* (1994).

Research Vessel Survey Indices - Indices of cod abundance (stratified mean catch per tow in numbers) and biomass (stratified mean weight per tow in kilograms), developed from Northeast Fisheries Science Center (NEFSC) and Commonwealth of Massachusetts research vessel bottom trawl surveys, have been used to monitor changes and assess trends in population size and recruitment of USA cod populations since 1963. Offshore (> 27 m) stratified random NEFSC surveys have been conducted annually in the Gulf of Maine in autumn since 1963 and in spring since 1968. Inshore areas (< 27 m) have been sampled since 1978 during spring and autumn NEFSC and Commonwealth of Massachusetts inshore bottom trawl surveys. For the NEFSC surveys, a "36 Yankee" trawl has been the standard sampling gear except for spring 1973-1981 when a modified "41 Yankee" trawl was used.

Prior to 1985, BMV oval doors (550 kg) were used in all NEFSC surveys; since 1985, Portuguese polyvalent doors (450 kg) have been used. Details on NEFSC survey sampling design and procedures are provided in Azarovitz (1981) and Clark (1981). The Commonwealth of Massachusetts inshore bottom trawl sampling program is described in Howe et al. (1981). No adjustments in the survey catch per tow data for cod have been made for any of the trawl differences, but vessel and door coefficients have been applied to adjust the stratified means (number and weight per tow) as described in Table 15. Unadjusted catch per tow (number) at age indices from NEFSC spring and autumn surveys are listed in Appendix 1:Table 1 and standardized catch per tow (number) at age indices are listed in Appendix 1:Table 2. Catch per tow (number) at age indices from Massachusetts spring and autumn surveys are listed in Appendix 1:Table 3.

NEFSC spring and autumn offshore catch per tow indices for Gulf of Maine cod have generally exhibited similar trends throughout the survey time series (Table 15, Figure 4). Number per tow indices declined during the mid- and late 1960s but since 1972-73 have fluctuated as a result of a series of recruitment pulses. Sharp increases in the number per tow indices reflect above average recruitment of the 1971, 1973, 1977-1980, 1983, and 1985-1987 year classes at ages 1 and 2 (Appendix 1:Table 2, Figure 5). The sequential dominance of these cohorts at older ages can be discerned from number per tow at age values in both spring and autumn NEFSC surveys (Appendix 1:Table 2).

Spring NEFSC number per tow indices have remained relatively stable since 1985 at a level below the 1981-1984 period (Table 15); spring weight per tow indices have also remained relatively low through 1991 but the index increased substantially in 1992, and remained relatively high in 1993, due to a large contribution from the 1987 year class (Appendix 1:Table 2). The 1994 spring index, however, declined markedly. Autumn number and weight per tow indices declined sharply in 1991 to unprecedented low levels, and weight per tow has continued to decline to new record low levels through 1993. The increased abundance levels in 1988 and 1989, resulting from recruitment of the strong 1986 and 1987 year classes, was depleted by 1991, resulting in the sharp declines in the overall index. This reduction, combined with a general paucity of large fish in the survey indices (Appendix 1:Table 2) in recent years has resulted in the sharp decline in the weight per tow indices since 1991 as well. Overall, the 1987 year class appears to have been one of the strongest ever produced; catch per tow indices of this cohort at ages 1-3 in the NEFSC autumn surveys and at ages 0 and 1 in the Massachusetts DMF autumn inshore surveys were nearly all record-high values (Appendix 1:Tables 2 and 3). Based on Massachusetts DMF survey catch per tow indices in 1989-1994, the 1993 year class may be above average, but the remaining year classes of Gulf of Maine cod appear to be only average or below-average.

MORTALITY

Total Mortality Estimates - Pooled estimates of instantaneous total mortality (Z) were calculated for eight time periods encompassed by the NEFSC spring and autumn offshore surveys: 1964-1967, 1968-1972, 1973-1976, 1977-1981, 1982-1984, 1985-1987, and 1988-1990 (Table 16). Total mortality was calculated from survey catch per tow at age data (Appendix 1:Table 2) for fully recruited age groups (age 3+) by the $\log_e$ ratio of the pooled age 3+/age 4+ indices in the autumn surveys, and the pooled age 4+/age 5+ indices in the spring surveys. For example, the 1982-1984 values were derived from:

Spring: ln (Σ age 4+ for 1982-84/ Σ age 5+ for 1983-85)

Autumn: ln (Σ age 3+ for 1981-83/ Σ age 4+ for 1982-84)

Different age groups were used in the spring and autumn analyses so that Z could be evaluated over identical year classes within each time period.

Except for the 1988-1990 period, values of Z derived from the spring surveys are slightly lower than those calculated from the autumn data. Rather than selecting one survey series over the other, total mortality was calculated by taking a geometric mean of the spring and autumn estimates in each time period. The pooled estimates indicate that total mortality was relatively low (Z = 0.40) between 1964 and 1976 but significantly increased afterward to 0.75-0.78 during 1982-1987. Total mortality increased further to 0.94 during the 1988-1990 and to 1.10 during 1991-1993.

Natural Mortality - Instantaneous natural mortality (M) for Gulf of Maine cod is assumed to be 0.20, the conventional value of M used for all Northwest Atlantic cod stocks (Paloheimo and Koehler 1968; Pinhorn 1975; Minet 1978).

ESTIMATION of FISHING MORTALITY RATES and STOCK SIZE

Virtual Population Analysis Calibration - The ADAPT (Parrack 1986, Gavaris 1988, Conser and Powers 1990) calibration method was used to derive estimates of terminal F values in 1993. As in previous assessments, age-disaggregated analyses were performed. Several exploratory ADAPT formulations were performed using NEFSC spring and autumn (ages 2-6), Massachusetts DMF spring (ages 2-4) and autumn (ages 2 and 3) and USA commercial LPUE (ages 3-6) abundance indices. The NEFSC and Massachusetts DMF autumn indices were lagged by one age and one year whereby age 1-6 indices were related to age 2-6 stock sizes in the subsequent year for corresponding cohorts. All NEFSC and Massachusetts DMF indices were related to January 1 stock sizes and USA commercial LPUE indices were related to mid-year stock sizes. In contrast to previous assessments, the USA commercial LPUE indices were derived from the catch at age corresponding to the effort subfleet used in the estimation of standardized fishing effort as described by Mayo et *al.* (1994).

The 1982-1993 catch at age as provided in Table 6 was included in the initial trial run. The initial calibration, employing the full age complement (true ages 2-9), produced high coefficients of variation (CV) on the 1994 stock size estimates and variable estimates of F on ages 7-9 in most years prior to the terminal year. Therefore, subsequent trial formulations employed reduced age ranges (2-6, 7+ and 2-7, 8+) as in the previous assessment of this stock (Mayo *et al.* 1993).

As in the past, Massachusetts DMF survey data were included in the VPA calibration primarily to improve the estimates of recruiting year class strength. In exploratory analyses the DMF autumn age 3 (age 2 before lagging) index often accounted for up to 40% of the total sum of squares; this index was, as in previous assessments, excluded from the final calibration. A summary of a series of trial formulations is provided in Table 17. All of the trial calibrations employed equal weighting among indices and in all years. The formulation identical to that employed in the previous assessment is presented first. As in all subsequent trials, a rather sharp decline in the 1993 F between ages 4 and 5 is evident in these results, although the CVs are similar among trials. The F pattern in 1992 was also rather unstable in all formulations carried out to a true age of 7 years. Therefore, a final set of trials was attempted with the last true age set at 6. These formulations produced a more stable F pattern in 1992, although the abrupt change between ages 4 and 5 in 1993 still remained. Noting the reduced contribution of older ages in the catch in recent years, a final calibration was performed with the age range reduced to ages 2-6 and a 7+ group as indicated by the last formulation in Table 17. This represents the only departure from the last assessment.

The ADAPT formulation employed in the final VPA calibration provided direct stock size estimates for ages 2 through 6 in 1994 and corresponding estimates of F on ages 1 through 5 in 1993. Since the age at full recruitment was defined as 4 years in the input partial recruitment vector, the terminal year F on age 6 was estimated as the mean of the age 4 and 5 Fs; age 6 is also the oldest true age in the terminal year. In all years prior to the terminal year, F on the oldest true age (age 6) was determined from weighted estimates of Z for ages 4 through 6. In all years, the age 6 F was applied to the 7+ group. Spawning stock biomass (SSB) was calculated at spawning time (March 1) by applying a series of period-specific maturity ogives provided by O'Brien (pers. comm.).

Virtual Population Analysis Results - Full results from the final VPA calibration are presented in Appendix 2 and estimates of F, stock size, and spawning stock biomass are given in Table 18. Except for a few cases the final calibration yielded low correlations (< 0.10) among estimates of slopes (q) and moderately low correlations (< 0.20) between stock sizes and qs. The highest correlations were noted between stock size estimates and the NEFSC spring and autumn abundance index for the corresponding age (Appendix 2, page 10). All parameter estimates were significant. Coefficients of variation on the stock size estimates ranged from 0.23 (age 3) to 0.39 (age 6), while CVs on the estimates of slopes were between 0.16 and 0.17. Slopes of the abundance index-stock size relationships (Appendix 2, page 9) increased with age generally up to age 4 for the NEFSC spring and autumn surveys and the USA commercial LPUE indices. Slopes from the Massachusetts DMF indices did not exhibit noticeable trends.

Average (ages 4-5, unweighted) fishing mortality in 1993 was estimated at 0.93 (Table 18, Figure 6), a 10% decrease from 1992. This decrease in mean fully recruited F is consistent with the decrease in standardized fishing effort indicated by the General Linear Model (Figure 3). The spawning stock biomass of age 2 and older cod declined from 22,400 mt in 1982 to 14,100 mt in 1987. Folowing the recruitment and maturation of the strong 1987 year class, SSB increased sharply in 1989 to a maximum of 26,135 but declined to 9,391 mt in 1993 (Figure 7). Total (ages 2+) stock size has also declined sharply in recent years from 28 million fish in 1989 to 9.6 million in 1994 (Table 18).

Since 1982, recruitment at age 2 has ranged from approximately 2.6 million fish (1989 year class) to 17.8 million fish (1987 year class). Over the 1982-1993 period, geometric mean recruitment for the 1980-1991 year classes equalled 5.4 million fish. The 1987 year class is the highest in the 1982-1993 series and about twice the size of the above average 1980 and 1986 year classes. Recent recruitment, however, has been poor as the 1988-1991 year classes (all $\leq$ 4.5 million at age 2) are estimated to be among the poorest in the series (Table 18). The 1990 year class, which accounted for a high proportion of the number landed in 1993 (Table 6) was estimated to be slightly below average.

Precision of F and SSB - To evaluate the precision of the final estimates, a bootstrap procedure (Efron 1982) was used to generate distributions of the 1993 fishing mortality rate and spawning stock biomass. Figures 8 and 9 show the distribution of the bootstrap estimates and a cumulative probability curve. The cumulative probability expresses the likelihood that the fishing mortality rate was greater than a given level (Figure 8) or the likelihood that spawning stock biomass was less than a given level (Figure 9) when measurement error is considered. An evaluation of the precision of the 1994 stock size, q, 1993 fishing mortality, and 1993 spawning stock biomass estimates is presented in Appendix 3.

Coefficients of variation (C.V.) for the 1994 stock size estimates ranged from 0.23 (age 3) to 0.42 (age 6), and C.V.s for qs among all indices ranged from 0.15 to 0.17. The fully recruited fishing mortality for ages 4+ was reasonably well estimated (C.V. = 0.16). The mean bootstrap estimate of F (0.939) was slightly higher than the point estimate (0.928) from the VPA (Appendix 3) and ranged from 0.60 to 1.5 (Figure 8). $F_{20\%}$ is much lower than the lowest bootstrap estimate and F_{1993} is almost certainly above the overfishing definition mortality rate.

Although the abundance estimates of individual ages in 1994 had wider variances (C.V. = 0.23 to 0.42), the estimate of 1993 spawning stock biomass was robust (C.V. = 0.09). The bootstrap mean (9,882 mt) was slightly higher than the VPA point estimate (9,727) (Appendix 3) and ranged from 7,500 mt to 13,500 mt (Figure 9). Current spawning stock biomass is the lowest observed in the series.

Retrospective Analysis - Retrospective analyses of the Gulf of Maine cod VPA were carried out using the final ADAPT formulation with the terminal year ranging from 1993 back to 1988. Results are given in Table 19 and Figure 10. Convergence of estimates is generally evident within 3 years, and often within 2 years, prior to any given terminal year. Retrospective patterns are evident for Gulf of Maine cod, particularly with respect to terminal F. Mean (ages 4-5, unweighted) F was generally over-estimated by the ADAPT calibration and age 2 recruits and SSB were most often under-estimated. Terminal Fs appear to have been well estimated since 1989. Despite these patterns, the retrospective analysis provides additional evidence to substantiate the current high levels of F.

Retrospective patterns for SSB and age 2 recruits are similar, both indicating relatively consistent estimates of terminal year values from 1988-1993. Although subject to some variability, terminal year recruitment and SSB appear to have been estimated with a high degree of reliability.

YIELD and SPAWNING STOCK BIOMASS per RECRUIT

Yield-per-recruit, total stock biomass per recruit, and spawning stock biomass per recruit analyses were performed using the Thompson and Bell (1934) method. Mean weights at age for application to yield per recruit were computed as a four-year arithmetic average of catch mean weights at age (Table 7) over the 1990-1993 period. Mean weights at age for application to SSB per recruit were computed as a four-year arithmetic average of stock mean weights at age (Table 8) over the 1990-1993 period. The maturation ogive was the same as used in computing SSB during the 1990-1993 period in the VPA. To obtain the exploitation pattern for these analyses, a five-year geometric mean F at age was first computed over the period 1988-1992 from the final converged VPA results. A smoothed exploitation pattern was then obtained by dividing the F at age by the mean unweighted F for ages 4-5. The final exploitation pattern is as follows:

Age 1 0.000, Age 2 0.054, Age 3 0.402, Age 4 0.878, Age 5+ 1.000

This pattern is similar to that presented in the 1992 Gulf of Maine cod assessment (Mayo et *al.* 1993), and was used in yield and SSB per recruit calculations. Input data and results of the yield and SSB per recruit calculations are listed in Table 20 and are illustrated in Figure 11. The yield per recruit analyses indicate that $F_{0.1} = 0.16$, $F_{max} = 0.27$, and SSB per recruit calculations indicate that $F_{20\%} = 0.35$.

SHORT-TERM AND MEDIUM-TERM PROJECTIONS

Recruitment - Short-term and medium-term projections of spawning stock biomass, recruitment at age 2 and commercial landings were performed using the VPA-calibrated 1993 fully recruited mean F (ages 4-5, u) and 1994 stock size estimates from the 300 bootstrap replications as starting conditions. Recruitment was generated based on the model 2 formulation of Brodziak and Rago (MS 1994). In this model age 2 recruitment is estimated two years ahead as a function of the existing level of SSB and a R/SSB ratio drawn from the empirical distribution of R/SSB ratios from 1982-1993 (1980-1991 year classes). The stochastic simulations were repeated 50 times to obtain a series of probability profiles for each projected variable. The exploitation pattern, mean weights and maturation rates were as described above for the yield and SSB per recruit analyses.

Short-Term Projection Results - Short-term projections are provided over a range of F levels which includes F_{max}, $F_{20\%}$, 50% of F_{SQ}, 90% of F_{SQ} and F_{SQ}. Input and output from the projections are given in Table 21. The assumption of status quo F in 1994 of 0.93 resulted in a 1994 catch of approximately 6,600 mt. Given the delayed implementation of Amendment 5 effort restrictions in 1994, the assumption of status quo F in 1994 appears reasonable.

Continued fishing at F = 0.93 in 1995 will result in projected 1995 landings of about 6,900 mt and will result in a continued decline in SSB to 6,500 mt in 1996 from the record low 1994 level of 8,100 mt (Table 21, Figure 12). SSB is projected to decline even further in 1997 if F remains at the current level in 1996. If fishing mortality is reduced to $F_{20\%}$ (0.35) in 1995 and 1996, SSB is projected to increase from the low 1994 level to 10,400 mt in 1996 (Table 21, Figure 12) and 12,400 mt in 1997.

Medium-Term Projection Results - Stock sizes and landings were projected through 2005 from starting conditions described above with the same age-specific mean weights, maturity and partial recruitment used for the short-term projections. Results are presented graphically for spawning stock biomass, and commercial landings in Figure 13. The central heavy line represents the 50% probability (median) outcomes and the accompanying lighter lines represent the 10%, 25%, 75% and 90% probability outcomes. Medium-term projections were run for 2 F levels: 1) status quo F (0.93) applied throughout 1995-2005, and 2) $F_{20\%}$ (0.35) applied throughout 1995-2005. The status quo F (0.93) was applied in all cases in 1994.

Under status quo F levels, the median outcomes suggest that SSB will decline to about 2,000 mt in 2005 as recruitment declines to less than 1 million fish per year after 2000. Commercial landings follow a similar trajectory (Figure 13). If fishing mortality is reduced from the present level by about 60% in 1995 and thereafter, median projection results indicate a slow increase in SSB, reaching about 28,000 mt by 2005 as median recruitment increases to about 7 million fish (Figure 13). This level of SSB is about equal to that realized in 1989 following the maturation of the relatively strong 1987 year class; the projected SSB, however, will consist of several moderate year classes instead of a single dominant year class as in 1989. After declining initially, landings are projected to increase to about 10,000 mt level by 2005.

The medium-term projections do not account for compensatory growth or maturation effects. Therefore, it is very possible that the increase in SSB projected through 2005 under the $F_{20\%}$ scenario may not be realized. In addition, the projected declines in SSB under the status quo F scenario are well below the range of observed values; the behavior of the stock and recruitment trajectories at such low stock sizes cannot be predicted from prior observation.

CONCLUSIONS

The Gulf of Maine cod stock is presently at a low biomass level and is over exploited. Fishing mortality in 1993 (0.93) declined slightly from the 1992 level (1.03) while spawning stock biomass (SSB) has declined from over 26,000 mt in 1989 to record low levels of 9,400 mt in 1993 and 8,100 mt in 1994. Accounting for the estimation uncertainty associated with the 1993 SSB (9,727 mt) and 1993 F (0.93) estimates, there is an 80% probability that the 1993 SSB lies between 8,800 mt and 11,200 mt, and that the 1993 F lies between 0.75 and 1.15. This further implies a 90% probability that the 1993 F is greater than 0.75, or about two times greater than the over fishing definition ($F_{20\%}$=0.35).

At the present level of exploitation and probable levels of recruitment in the near term, the decline in spawning stock biomass is expected to continue. If the current level of exploitation continues, landings are expected to decline to less than 7,000 mt in 1995 and spawning stock biomass is projected to decline to about 6,500 mt in 1996. Current SSB is no longer dominated by the 1987 year class, but by a series of very low to below average year classes produced from 1988-1991.

Rebuilding of the stock will require a substantial reduction in fishing mortality. If fishing mortality is not reduced from the present level, SSB will decline to about 2,000 mt in 2005 as recruitment declines to less than 1 million fish per year after 2000. If fishing mortality is reduced by about 60% in 1995 and thereafter, SSB will increase slowly to about 28,000 mt by 2005 and recruitment will average about 7 million fish. Under this reduced level of F, landings are projected to decline initially but are expected to increase to about 10,000 mt by 2005.

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Table 1. Commercial landings (metric tons, live) of Atlantic cod the Gulf of Maine (NAFO Division 5Y), 1960 - 1993.[1]

	Gulf of Maine				
Year	USA	Canada	USSR	Other	Total
1960	3448	129	-	-	3577
1961	3216	18	-	-	3234
1962	2989	83	-	-	3072
1963	2595	3	133	-	2731
1964	3226	25	-	-	3251
1965	3780	148	-	-	3928
1966	4008	384	-	-	4392
1967	5676	297	-	-	5973
1968	6360	61	-	-	6421
1969	8157	59	-	268	8484
1970	7812	26	-	423	8261
1971	7380	119	-	163	7662
1972	6776	53	11	77	6917
1973	6069	68	-	9	6146
1974	7639	120	-	5	7764
1975	8903	86	-	26	9015
1976	10172	16	-	-	10188
1977	12426	-	-	-	12426
1978	12426	-	-	-	12426
1979	11680	-	-	-	11680
1980	13528	-	-	-	13528
1981	12534	-	-	-	12534
1982	13582	-	-	-	13582
1983	13981	-	-	-	13981
1984	10806	-	-	-	10806
1985	10693	-	-	-	10693
1986	9664	-	-	-	9664
1987	7527	-	-	-	7527
1988	7958	-	-	-	7958
1989	10397	-	-	-	10397
1990	15154	-	-	-	15154
1991	17781	-	-	-	17781
1992	10891	-	-	-	10891
1993*	8287	-	-	-	8287

[1] USA landings from NMFS, NEFC Detailed Weighout Files and Canvass data.

* Provisional

Table 2. Distribution of USA commercial landings (metric tons, live) of Atlantic cod from the Gulf of Maine (Area 5Y), by gear type, 1965 - 1993. The percentage of total USA commercial landings of Atlantic cod from the Gulf of Maine, by gear type, is also presented for each year. Data only reflect Gulf of Maine cod landings that could be identified by gear type.

	Landings (metric tons, live)						Percentage of Annual Landings					
Year	Otter Trawl	Sink Gill Net	Line Trawl	Handline	Other Gear	Total	Otter Trawl	Sink Gill Net	Line Trawl	Handline	Other Gear	Total
1965	2480	501	462	168	1	3612	68.7	13.9	12.8	4.6	-	100.0
1966	2549	830	308	150	4	3841	66.4	21.6	8.0	3.9	0.1	100.0
1967	4312	734	206	274	<1	5526	78.0	13.3	3.7	5.0	-	100.0
1968	4143	1377	213	339	4	6076	68.2	22.7	3.5	5.6	-	100.0
1969	6553	851	258	162	4	7828	83.7	10.9	3.3	2.1	-	100.0
1970	5967	951	407	178	9	7512	79.4	12.7	5.4	2.4	0.1	100.0
1971	5117	1043	927	98	8	7193	71.1	14.5	12.9	1.4	0.1	100.0
1972	4004	1492	1234	54	2	6786	59.0	22.0	18.2	0.8	-	100.0
1973	3542	1182	1305	23	9	6061	58.4	19.5	21.5	0.4	0.2	100.0
1974	5056	1412	904	36	17	7425	68.1	19.0	12.2	0.5	0.2	100.0
1975	6255	1480	920	12	8	8675	72.1	17.1	10.6	0.1	0.1	100.0
1976	6701	2511	621	4	41	9878	67.8	25.4	6.3	0.1	0.4	100.0
1977	8415	2872	534	6	166 [a]	11993	70.2	23.9	4.5	-	1.4	100.0
1978	7958	3438	393	10	91 [b]	11890	66.9	28.9	3.3	0.1	0.8	100.0
1979	7567	2900	334	19	167 [c]	10987	68.9	26.4	3.0	0.2	1.5	100.0
1980	8420	3733	251	48	61	12513	67.3	29.8	2.0	0.4	0.5	100.0
1981	7937	4102	276	23	45	12383	64.1	33.1	2.2	0.2	0.4	100.0
1982	9758	3453	188	46	34	13479	72.4	25.6	1.4	0.3	0.3	100.0
1983	9975	3744	77	4	67	13867	71.9	27.0	0.6	-	0.5	100.0
1984	6646	3985	22	3	69	10725	62.0	37.2	0.2	-	0.6	100.0
1985	7119	3090	55	6	326 [d]	10596	67.2	29.1	0.5	0.1	3.1	100.0
1986	6664	2692	56	12	180 [e]	9604	69.4	28.0	0.6	0.1	1.9	100.0
1987	4356	2994	70	13	68	7501	58.1	39.9	0.9	0.2	0.9	100.0
1988	4513	3308	68	27	22	7938	56.9	41.7	0.8	0.3	0.3	100.0
1989	6152	4000	72	36	119 [f]	10379	59.3	38.5	0.7	0.4	1.1	100.0
1990	10420	4343	126	20	186 [g]	15095	69.0	28.8	0.8	0.1	1.2	100.0
1991	13049	4158	212	59	266 [h]	17744	73.5	23.4	1.2	0.3	1.5	100.0
1992	7344	3081	359	94	14	10891	67.4	28.3	3.3	0.9	0.1	100.0
1993	4876	3130	236	16	29	8287	58.8	37.8	2.8	0.2	0.3	100.0

[a] Of 166 mt landed, 107 mt were by mid-water pair trawl and 42 mt were by drifiting gill nets.
[b] Of 91 mt landed, 56 mt were by Danish seine and 27 mt were by drifting gill nets.
[c] Of 167 mt landed, 199 mt were by drifting gill nets and 38 mt were by Danish seine.
[d] Of 326 mt landed, 268 mt were by longline and 37 mt were by Danish seine.
[e] Of 181 mt landed, 152 mt were by longline and 23 mt were by Danish seine.
[f] Of 199 mt landed, 75 mt were by longline and 27 mt were by Danish seine.
[g] Of 186 mt landed, 159 mt were by longline and 16 mt were by Danish seine.
[h] Of 266 mt landed, 245 mt were by longline and 9 mt were by Danish seine.

Table 3. Estimated number (000's) and weight (metric tons, live) of Atlantic cod caught by marine recreational fishermen, in 1960, 1965, 1970, 1974, and 1979 - 1993.[1]

Year	All Regions		Gulf of Maine Stock		Gulf of Maine Stock	
	No. of Cod (000's)	Wt. of Cod (mt)	No. of Cod (000's)	Wt. of Cod (mt)	Mean Weight (kg)	Percent of Total Landings
1960	4791	14016	Not Estimated		-----	-----
1965	5032	13565	Not Estimated		-----	-----
1970	3844	16292	Not Estimated		-----	-----
1974	2901	12368	Not Estimated		-----	-----
1979	3091	4026	2698	3446	1.277	22.8
1980	2440	7331	2254	6860	3.043	33.6
1981	4845	9712	3240	5035	1.554	28.7
1982	3250	8244	1797	2948	1.641	17.8
1983	3747	7542	2054	2622	1.277	15.8
1984	2562	5080	1730	2674	1.546	19.8
1985	3674	7664	1676	3029	1.807	22.1
1986	1548	3510	1217	2418	1.987	20.0
1987	2063	3779	1596	2611	1.636	25.8
1988	2966	7327	1472	3043	2.067	27.7
1989	2463	6119	1925	4244	2.205	29.0
1990	2635	5144	1945	3448	1.773	18.5
1991	1854	3727	1410	2472	1.753	12.2
1992	721	1516	512	1009	1.971	8.5
1993	2282	4874	1392	2667	1.916	24.3

[1] From 1979-1993 Marine Recreational Fishery Statistics Survey expanded catch estimates.

Table 4. USA sampling of commercial Atlantic cod landings from the Gulf of Maine cod stock (NAFO Division 5Y), 1982 - 1993.

Year	Number of Samples				Number of Samples, by Market Category & Quarter														Annual Sampling Intensity			
	Length Samples		Age Samples		Scrod					Market					Large					No. of Tons Landed/Sample			
	No.	# Fish Measured	No.	# Fish Aged	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Scd	Mkt	Lge	Σ
1982	48	3848	48	866	6	7	6	6	**25**	4	3	7	4	**18**	0	2	1	2	**5**	134	348	792	266
1983	71	5241	67	1348	14	10	10	4	**38**	4	10	6	2	**22**	1	3	5	2	**11**	106	294	318	197
1984	55	3925	55	1224	7	5	6	7	**25**	4	3	5	6	**18**	1	6	3	2	**12**	85	319	245	193
1985	69	5426	66	1546	5	6	7	5	**23**	8	6	7	4	**25**	7	5	3	6	**21**	95	229	132	155
1986	53	3970	51	1160	5	5	6	3	**19**	5	6	8	2	**21**	1	5	4	3	**13**	124	242	170	182
1987	43	3184	42	939	4	4	3	4	**15**	5	5	3	5	**18**	4	2	3	1	**10**	83	224	225	175
1988	34	2669	33	741	4	3	4	4	**15**	1	5	3	5	**14**	1	2	2	0	**5**	147	271	391	234
1989	32	2668	32	714	3	3	3	3	**12**	4	1	5	4	**14**	2	2	1	1	**6**	209	430	311	325
1990	39	2982	38	789	3	7	3	5	**18**	4	7	4	3	**18**	0	2	1	0	**3**	300	378	966	387
1991	56	4519	56	1152	2	10	4	3	**19**	5	11	11	3	**30**	0	3	3	1	**7**	250	313	519	318
1992	51	4086	51	1002	2	8	6	3	**19**	6	7	7	3	**23**	3	1	1	4	**9**	104	232	375	214
1993	23	1753	23	447	3	3	3	1	**10**	1	2	4	1	**8**	1	1	2	1	**5**	177	453	527	360

Source: 1978-1985 from Serchuk and Wigley (Woods Hole Lab. Ref 86-12); 1986-1993 from NEFSC files.

Table 5. Percentage (by weight) of USA commercial Atlantic cod landings from Georges Bank and South (NAFO Division 5Z and Statistical Area 6) and the Gulf of Maine (NAFO Division 5Y), by market category, 1964 - 1993.

	Georges Bank and South				Gulf of Maine			
Year	Large	Market	Scrod	Total [a]	Large	Market	Scrod	Total [a]
1964	45	47	8	100	29	59	12	100
1965	56	40	3	100	39	54	7	100
1966	53	37	10	100	42	48	10	100
1967	41	42	16	100	41	41	17	100
1968	34	46	19	100	47	43	9	100
1969	27	57	16	100	35	55	9	100
1970	30	62	8	100	43	52	6	100
1971	40	51	9	100	52	42	6	100
1972	37	53	10	100	58	35	7	100
1973	24	40	36	100	52	36	11	100
1974	24	59	17	100	39	33	28	100
1975	28	62	10	100	32	42	26	100
1976	34	48	18	100	29	45	20	100
1977	26	39	34	100	33	42	22	100
1978	29	60	11	100	38	44	17	100
1979	37	55	8	100	37	49	14	100
1980	41	47	12	100	36	45	19	100
1981	36	49	12	100	29	45	22	100
1982	31	47	22	100	29	45	24	100
1983	25	53	21	100	25	45	28	100
1984	31	56	12	100	26	51	19	100
1985	27	46	25	100	25	51	20	100
1986	30	47	21	100	22	51	23	100
1987	25	37	36	100	29	52	16	100
1988	27	47	24	100	26	45	23	100
1989	23	52	22	100	17	55	23	100
1990	32	44	22	100	34	43	19	100
1991	31	48	19	100	26	51	20	100
1992	26	41	30	100	31	49	18	100
1993	--	--	--	100	32	44	21	100

[a] Includes landings of 'mixed' cod.

Table 6. Catch at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 1993.

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
Total Commercial Catch in Numbers (000's) at Age												
1982	30	1380	1633	1143	633	69	91	61	41	4	33	5118
1983	-	866	2357	1058	638	422	47	61	23	9	15	5496
1984	4	446	1240	1500	437	194	74	19	15	11	17	3957
1985	-	407	1445	991	630	128	78	32	4	11	11	3737
1986	-	84	2164	813	250	177	39	24	20	4	8	3583
1987	2	216	595	1109	277	66	51	9	8	8	3	2344
1988	-	160	1443	953	406	43	9	17	1	2	1	3035
1989	-	337	1583	1454	449	81	35	6	3	5	7	3960
1990	-	205	3425	2064	430	157	27	30	10	15	17	6380
1991	-	344	934	4161	851	143	41	30	6	1	1	6512
1992	-	313	530	484	2018	202	62	7	12	3	-	3631
1993	-	76	1487	641	129	457	28	6	2	-	-	2825
Total Commercial Catch in Weight (Tons) at Age												
1982	24	1595	2717	3160	3019	461	813	608	531	41	613	13582
1983	-	1009	3913	2619	2410	2518	271	643	227	102	269	13981
1984	3	516	2071	4080	1607	1145	603	186	193	152	250	10816
1985	-	513	2523	2816	2814	705	615	363	51	141	152	10693
1986	-	110	3976	2375	1153	1072	296	243	253	54	132	9664
1987	2	283	1001	3641	1340	451	455	88	116	110	40	7527
1988	-	203	2715	2311	2097	295	85	191	11	36	14	7958
1989	-	420	2811	4351	1737	325	323	67	43	87	163	10397
1990	-	219	5794	4687	1834	1200	290	354	153	214	350	15095
1991	-	388	1463	10455	3520	1045	399	369	93	32	17	17781
1992	-	480	1019	1313	6175	1011	594	88	161	49	-	10891
1993	-	99	2809	1611	561	2819	281	79	27	-	-	8286
Total Commercial Catch Mean Weight (kg) at Age												
1982	0.801	1.156	1.664	2.764	4.770	6.739	8.944	9.931	12.922	10.618	18.456	2.654[a]
1983	-	1.164	1.660	2.475	3.778	5.962	5.808	10.522	10.089	10.898	17.813	2.544
1984	0.589	1.159	1.670	2.721	3.677	5.898	8.119	9.595	12.889	13.951	15.028	2.731
1985	-	1.260	1.746	2.840	4.466	5.525	7.901	11.218	11.420	13.386	14.523	2.861
1986	-	1.304	1.837	2.923	4.619	6.067	7.669	10.030	12.463	12.907	16.554	2.698
1987	1.028	1.313	1.684	3.283	4.831	6.824	8.878	10.023	13.752	14.738	14.596	3.212
1988	-	1.268	1.881	2.426	5.166	6.767	9.932	11.126	14.960	15.763	20.356	2.622
1989	-	1.247	1.776	2.993	3.864	4.872	9.267	11.938	14.806	18.196	21.521	2.626
1990	-	1.071	1.692	2.271	4.265	7.645	10.734	11.758	15.015	14.784	20.295	2.366
1991	-	1.130	1.568	2.512	4.136	7.309	9.642	12.322	15.547	24.328	21.885	2.731
1992	-	1.533	1.922	2.714	3.061	5.000	9.566	12.462	13.449	16.631	-	2.999
1993	-	1.293	1.889	2.513	4.356	6.174	9.999	13.869	17.544	-	-	2.933
Total Commercial Catch Mean Length (cm) at Age												
1982	43.2	48.3	53.8	63.4	76.8	86.1	94.6	97.9	107.4	101.0	120.7	59.9[b]
1983	-	48.6	53.8	61.4	70.8	82.4	80.5	98.8	97.5	100.0	118.7	59.8
1984	39.0	48.4	54.1	63.4	69.7	81.8	91.5	96.7	106.9	109.6	112.0	61.6
1985	-	49.8	55.1	64.6	74.9	80.3	90.8	101.9	103.1	108.2	109.7	62.8
1986	-	50.3	55.9	65.0	75.4	82.6	89.9	98.7	105.8	107.5	116.2	61.6
1987	47.0	50.4	54.4	67.8	76.9	86.5	93.8	98.7	109.5	111.7	111.3	65.4
1988	-	50.1	56.4	61.1	78.7	86.4	98.6	102.3	113.0	114.8	125.0	61.4
1989	-	49.8	55.5	65.7	71.5	76.7	95.8	103.4	112.6	120.4	126.8	61.7
1990	-	47.5	54.8	60.0	73.7	90.0	100.9	104.0	111.8	112.6	124.6	59.2
1991	-	47.7	52.6	61.8	72.6	88.6	97.2	105.0	113.3	132.5	128.0	62.2
1992	-	53.1	56.6	62.9	65.6	77.0	97.3	106.1	109.1	117.0	-	64.3
1993	-	50.5	56.8	61.7	74.2	83.7	98.6	110.0	119.1	-	-	63.5

[a] Mean weight.
[b] Mean length.

Table 7. Catch at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 1993.

Year	Age 1	2	3	4	5	6	7+	Total
Total Commercial Catch in Numbers (000's) at Age								
1982	30	1380	1633	1143	633	69	230	5118
1983	-	866	2357	1058	638	422	155	5496
1984	4	446	1240	1500	437	194	136	3957
1985	-	407	1445	991	630	128	136	3737
1986	-	84	2164	813	250	177	95	3583
1987	2	216	595	1109	277	66	79	2344
1988	-	160	1443	953	406	43	30	3035
1989	-	337	1583	1454	449	81	56	3960
1990	-	205	3425	2064	430	157	99	6380
1991	-	344	934	4161	851	143	79	6512
1992	-	313	530	484	2018	202	84	3631
1993	-	76	1487	641	129	457	36	2825
Total Commercial Catch in Weight (Tons) at Age								
1982	24	1595	2717	3160	3019	461	2606	13582
1983	-	1009	3913	2619	2410	2518	1512	13981
1984	3	516	2071	4080	1607	1145	1384	10816
1985	-	513	2523	2816	2814	705	1322	10693
1986	-	110	3976	2375	1153	1072	978	9664
1987	2	283	1001	3641	1340	451	809	7527
1988	-	203	2715	2311	2097	295	337	7958
1989	-	420	2811	4351	1737	325	683	10397
1990	-	219	5794	4687	1834	1200	1361	15095
1991	-	388	1463	10455	3520	1045	910	17781
1992	-	480	1019	1313	6175	1011	892	10891
1993	-	99	2809	1611	561	2819	387	8286
Total Commercial Catch Mean Weight (kg) at Age								
1982	0.801	1.156	1.664	2.764	4.770	6.739	11.330	2.654[a]
1983	-	1.164	1.660	2.475	3.778	5.962	9.755	2.544
1984	0.589	1.159	1.670	2.721	3.677	5.898	10.176	2.731
1985	-	1.260	1.746	2.840	4.466	5.525	9.721	2.861
1986	-	1.304	1.837	2.923	4.619	6.067	10.295	2.698
1987	1.028	1.313	1.684	3.283	4.831	6.824	10.241	3.212
1988	-	1.268	1.881	2.426	5.166	6.767	11.233	2.622
1989	-	1.247	1.776	2.993	3.864	4.872	12.200	2.626
1990	-	1.071	1.692	2.271	4.265	7.645	13.747	2.366
1991	-	1.130	1.568	2.512	4.136	7.309	11.449	2.731
1992	-	1.533	1.922	2.714	3.061	5.000	10.614	2.999
1993	-	1.293	1.889	2.513	4.353	6.174	11.063	2.933
Total Commercial Catch Mean Length (cm) at Age								
1982	43.2	48.3	53.8	63.4	76.8	86.1	101.6	59.9[b]
1983	-	48.6	53.8	61.4	70.8	82.4	95.1	59.8
1984	39.0	48.4	54.1	63.4	69.7	81.8	98.0	61.6
1985	-	49.8	55.1	64.6	74.9	80.3	96.7	62.8
1986	-	50.3	55.9	65.0	75.4	82.6	98.4	61.6
1987	47.0	50.4	54.4	67.8	76.9	86.5	98.4	65.4
1988	-	50.1	56.4	61.1	78.7	86.4	103.1	61.4
1989	-	49.8	55.5	65.7	71.5	76.7	103.6	61.7
1990	-	47.5	54.8	60.0	73.7	90.0	108.8	59.2
1991	-	47.7	52.6	61.8	72.6	88.6	102.2	62.2
1992	-	53.1	56.6	62.9	65.6	77.0	100.4	64.3
1993	-	50.5	56.8	61.7	74.2	83.7	101.6	63.5

[a] Mean weight.
[b] Mean length.

Table 8. Mean weight at age (kg) at the beginning of the year (January 1) for Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 1993. Values derived from catch mean weight-at-data (mid-year) using procedures described by Rivard (1980).

	Age									
Year	1	2	3	4	5	6	7	8	9	10+ [a]
1982	0.791	0.965	1.364	2.364	(3.750)	(5.600)	(7.400)	9.853	(11.650)	16.000
1983	0.793	1.024	1.385	2.029	3.231	5.333	6.256	9.701	10.010	16.000
1984	0.761	1.021	1.394	2.125	3.017	4.720	6.957	(9.670)	11.646	16.000
1985	0.748	1.065	1.423	2.178	3.486	4.507	6.826	9.544	10.468	16.000
1986	0.745	1.083	1.521	2.259	3.622	5.205	6.509	8.902	11.824	16.000
1987	0.758	1.087	1.482	2.456	3.758	5.614	7.339	8.767	11.744	16.000
1988	0.765	1.068	1.572	2.021	4.118	5.718	8.233	9.939	12.245	16.000
1989	0.825	1.059	1.501	2.373	3.062	5.017	7.919	10.889	12.835	16.000
1990	0.803	0.982	1.453	2.008	3.573	5.435	7.232	10.438	13.388	16.000
1991	0.690	1.008	1.296	2.062	3.065	5.583	8.586	11.501	13.520	16.000
1992	0.751	1.175	1.474	2.063	2.773	4.548	8.362	10.962	12.875	16.000
1993	0.751	1.079	1.702	2.198	3.438	4.347	7.071	11.518	13.261	16.000
Mean Values										
90-93	**0.749**	**1.061**	**1.481**	**2.083**	**3.212**	**4.978**	**7.813**	**11.105**	**13.261**	**16.000**
82-93	**0.765**	**1.051**	**1.464**	**2.178**	**3.408**	**5.136**	**7.391**	**10.140**	**12.123**	**16.000**

[a] Mean weight-at-age values for 10+ set equal to mean (1982-1993) catch (mid-year) weight at age value for 10+.

( ) Values in parentheses are modified from calculated values.

Table 9. USA commercial landings (L)[1], days fished (DF)[2], and landings per day fished (L/DF), by vessel tonnage class (Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT), of Atlantic cod for otter trawl trips catching cod from the Gulf of Maine (NAFO Division 5Y), 1965 - 1993. Data are also provided for otter trawl trips in which cod comprised 50% or more of the total trip catch, by weight ['directed trips'].

Year	Class 2			Class 3			Class 4			Totals	
	L	DF	L/DF	L	DF	L/DF	L	DF	L/DF	L	L/DF[3]
ALL TRIPS											
1965	1412	2691	0.52	935	965	0.97	46	92	0.50	2393	0.70
1966	1265	2379	0.53	1093	938	1.17	113	83	1.36	2471	0.85
1967	1790	2175	0.82	2341	1232	1.90	108	196	0.55	4239	1.41
1968	1839	2696	0.68	1955	1266	1.54	219	182	1.20	4013	1.13
1969	2992	3301	0.91	2874	1497	1.92	549	337	1.63	6415	1.42
1970	3359	4834	0.69	2010	1666	1.21	389	425	0.92	5758	0.89
1971	2917	4000	0.73	1727	1475	1.17	293	422	0.69	4937	0.88
1972	2190	4104	0.53	1463	1637	0.89	192	244	0.79	3845	0.68
1973	2018	3915	0.52	1172	1430	0.82	194	252	0.77	3384	0.64
1974	2292	3954	0.58	2108	1455	1.45	458	367	1.25	4858	1.02
1975	3108	4423	0.70	2599	1818	1.43	311	373	0.83	6018	1.02
1976	3168	4404	0.72	3143	2096	1.50	262	527	0.50	6573	1.08
1977	3816	4354	0.88	3903	2448	1.59	341	631	0.54	8060	1.21
1978	3859	5063	0.76	3334	2618	1.27	489	809	0.60	7682	0.97
1979	3731	5623	0.66	3169	2425	1.31	475	779	0.61	7375	0.94
1980	3967	6252	0.63	3497	3181	1.10	571	908	0.63	8035	0.83
1981	3722	4912	0.76	3253	3277	0.99	737	986	0.75	7712	0.86
1982	3619	6086	0.59	4466	4343	1.03	1281	1448	0.88	9366	0.84
1983	3473	5512	0.63	4874	4731	1.03	1326	1782	0.74	9673	0.85
1984	2188	5444	0.40	3217	5042	0.64	883	1668	0.53	6288	0.54
1985	1801	4890	0.37	3457	5921	0.58	1515	2675	0.57	6773	0.52
1986	1638	4721	0.35	3088	6149	0.50	1513	2990	0.51	6239	0.46
1987	1131	4782	0.24	2005	6417	0.31	1012	2724	0.37	4148	0.31
1988	1327	5089	0.26	2137	5446	0.39	830	2105	0.39	4294	0.35
1989	1559	4066	0.39	2885	5071	0.57	1334	1882	0.71	5778	0.55
1990	2004	4280	0.47	4748	5349	0.89	3211	2029	1.58	9963	1.03
1991	2466	4460	0.55	5272	6042	0.87	4318	2532	1.71	12056	1.11
1992	1682	4676	0.36	3400	6481	0.52	1901	2488	0.76	6983	0.55
1993	927	3761	0.25	2525	6236	0.40	1276	2041	0.63	4728	0.43
50% TRIPS											
1965	394	183	2.15	310	74	4.19	1	1	1.00	705	3.05
1966	253	92	2.75	329	85	3.87	12	4	3.00	594	3.38
1967	656	179	3.66	1202	270	4.45	1	1	1.00	1859	4.17
1968	656	155	4.23	995	224	4.44	50	16	3.13	1701	4.32
1969	1399	324	4.32	1384	292	4.74	104	38	2.74	2887	4.46
1970	1369	395	3.47	719	152	4.73	46	15	3.07	2134	3.89
1971	1033	370	2.79	540	124	4.35	74	24	3.08	1647	3.31
1972	621	283	2.19	322	88	3.66	46	11	4.18	989	2.76
1973	380	179	2.12	96	33	2.91	1	1	1.00	477	2.28
1974	467	186	2.51	529	92	5.75	181	31	5.84	1177	4.48
1975	1047	331	3.16	1039	232	4.48	66	14	4.71	2152	3.84
1976	1197	384	3.12	1277	308	4.15	22	6	3.67	2496	3.65
1977	1390	386	3.60	1825	334	5.46	44	6	7.33	3259	4.69
1978	1314	421	3.12	1373	297	4.62	48	7	6.86	2735	3.94
1979	1114	382	2.92	1233	287	4.30	46	7	6.57	2393	3.70
1980	1198	360	3.33	1205	283	4.26	99	22	4.50	2502	3.82
1981	1587	317	5.01	1218	273	4.46	98	15	6.53	2903	4.83
1982	1354	381	3.55	2296	499	4.60	334	54	6.19	3984	4.38
1983	1399	397	3.52	2609	603	4.33	224	29	7.72	4232	4.24
1984	478	215	2.22	941	313	3.01	21	5	4.20	1440	2.77
1985	438	269	1.63	1024	319	3.21	205	67	3.06	1667	2.78
1986	398	249	1.60	602	295	2.04	143	49	2.92	1143	2.00
1987	253	180	1.41	273	206	1.33	79	41	1.93	605	1.44
1988	426	366	1.16	936	551	1.70	136	74	1.84	1498	1.56
1989	827	600	1.38	1571	1046	1.50	435	281	1.55	2833	1.47
1990	1265	920	1.38	3404	1800	1.89	2015	814	2.48	6684	1.97
1991	1693	1307	1.30	3749	2391	1.57	3150	1410	2.23	8592	1.76
1992	979	909	1.08	2023	1374	1.47	570	336	1.70	3572	1.40
1993	349	406	0.86	1363	1025	1.33	421	270	1.56	2133	1.30

[1]Metric tons, live weight.

[2]Days fished with trawl on bottom; derived by dividing hours fished with trawl on bottom by 24.

[3]Total L/DF was derived by weighting individual tonnage class L/DF values by the percentage of total landings accounted for by each vessel class and summing over the three vessel class categories.

Table 10. USA commercial vessel trips (T), days fished (DF)[1], and average days fished per trip (DF/T), by vessel tonnage class (Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT), of Atlantic cod for otter trawl trips catching cod from the Gulf of Maine (NAFO Division 5Y), 1965 - 1993. Data are also provided for otter trawl trips in which cod comprised 50% or more of the total trip catch, by weight ['directed trips'].

Year	Class 2			Class 3			Class 4			Totals		
	T	DF	DF/T	T	DF	DF/T	T	DF	DF/T	T	DF	DF/T
ALL TRIPS												
1965	5354	2691	0.50	1145	965	0.84	60	92	1.53	6559	3748	0.57
1966	4637	2379	0.51	1130	938	0.83	38	83	2.18	5805	3400	0.59
1967	3903	2175	0.56	1277	1232	0.96	98	196	2.00	5278	3603	0.68
1968	3587	2696	0.75	1293	1266	0.98	99	182	1.84	4979	4144	0.83
1969	3679	3301	0.90	1494	1497	1.00	186	337	1.81	5359	5135	0.96
1970	4342	4834	1.11	1585	1666	1.05	214	425	1.99	6141	6925	1.13
1971	3908	4000	1.02	1272	1475	1.16	204	422	2.07	5384	5897	1.10
1972	3933	4104	1.04	1326	1637	1.23	130	244	1.88	5389	5985	1.11
1973	4688	3915	0.84	1241	1430	1.15	146	252	1.73	6075	5597	0.92
1974	5145	3954	0.77	1274	1455	1.14	193	367	1.90	6612	5776	0.87
1975	5498	4423	0.80	1437	1818	1.27	198	373	1.88	7133	6614	0.93
1976	4734	4404	0.93	1687	2096	1.24	228	527	2.31	6649	7027	1.06
1977	4664	4354	0.93	2010	2448	1.22	298	631	2.12	6972	7433	1.07
1978	4655	5063	1.09	1754	2618	1.49	444	809	1.82	6853	8490	1.24
1979	5218	5623	1.08	1777	2425	1.36	445	779	1.75	7440	8827	1.19
1980	5344	6252	1.17	2240	3181	1.42	396	908	2.29	7980	10341	1.30
1981	7131	4912	0.69	2879	3277	1.14	385	986	2.56	10395	9175	0.88
1982	7737	6086	0.79	3148	4343	1.38	448	1448	3.23	11333	11877	1.05
1983	7460	5512	0.74	3575	4731	1.32	446	1782	4.00	11481	12025	1.05
1984	7006	5444	0.78	3554	5042	1.42	403	1668	4.14	10963	12154	1.11
1985	6196	4890	0.79	3612	5921	1.64	649	2675	4.12	10457	13486	1.29
1986	4868	4721	0.97	3582	6149	1.72	700	2990	4.27	9150	13860	1.51
1987	4058	4782	1.18	3023	6417	2.12	604	2724	4.51	7685	13923	1.81
1988	4154	5089	1.23	2965	5446	1.84	489	2105	4.30	7608	12640	1.66
1989	3387	4066	1.20	2420	5071	2.10	412	1882	4.57	6219	11019	1.76
1990	3051	4280	1.40	2201	5349	2.43	515	2029	3.94	5767	11658	2.02
1991	3796	4460	1.17	2162	6042	2.79	540	2532	4.69	6498	13034	2.01
1992	3796	4676	1.23	2238	6481	2.90	431	2488	5.77	6465	13645	2.11
1993	2960	3761	1.27	2201	6236	2.83	373	2041	5.47	5534	12038	2.18
50% TRIPS												
1965	493	394	0.80	116	74	0.64	2	1	0.50	611	469	0.77
1966	241	253	1.05	102	84	0.82	2	4	2.00	345	341	0.99
1967	418	656	1.57	231	270	1.17	1	1	1.00	650	927	1.43
1968	386	656	1.70	251	224	0.89	7	16	2.29	644	896	1.39
1969	645	1399	2.17	325	292	0.90	15	38	2.53	985	1729	1.76
1970	695	1369	1.97	217	152	0.70	11	15	1.36	923	1536	1.66
1971	550	1033	1.88	193	124	0.64	7	24	3.43	750	1181	1.57
1972	492	621	1.26	134	88	0.66	9	11	1.22	635	720	1.13
1973	354	380	1.07	54	33	0.61	2	1	0.50	410	414	1.01
1974	491	467	0.95	98	92	0.94	17	31	1.82	606	590	0.97
1975	676	1047	1.55	218	232	1.06	11	14	1.27	905	1293	1.43
1976	554	1197	2.16	334	308	0.92	6	6	1.00	894	1511	1.69
1977	492	1390	2.83	391	334	0.85	10	6	0.60	893	1730	1.94
1978	460	1314	2.86	281	297	1.06	6	7	1.17	747	1618	2.17
1979	504	1114	2.21	331	287	0.87	10	7	0.70	845	1408	1.67
1980	500	1198	2.40	360	283	0.79	12	22	1.83	872	1503	1.72
1981	752	1587	2.11	390	273	0.70	13	15	1.15	1155	1875	1.62
1982	802	1354	1.69	565	499	0.88	23	54	2.35	1390	1907	1.37
1983	910	1399	1.54	855	603	0.71	24	29	1.21	1789	2031	1.14
1984	427	215	0.50	334	313	0.94	1	5	5.00	762	533	0.70
1985	397	269	0.68	331	319	0.96	18	67	3.72	746	655	0.88
1986	240	249	1.04	232	294	1.27	16	49	3.06	488	592	1.21
1987	164	180	1.10	121	206	1.70	15	41	2.73	300	427	1.42
1988	267	366	1.37	342	551	1.61	23	74	3.22	632	991	1.57
1989	454	600	1.32	515	1046	2.03	65	281	4.32	1034	1927	1.86
1990	537	920	1.71	780	1800	2.31	226	814	3.60	1543	3534	2.29
1991	1037	1307	1.26	803	2391	2.98	307	1410	4.59	2147	5108	2.38
1992	805	909	1.13	470	1374	2.92	86	336	3.91	1361	2619	1.92
1993	386	406	1.05	381	1025	2.69	58	270	4.66	825	1701	2.06

[1] Days fished with trawl on bottom; derived by dividing hours fished with trawl on bottom by 24.

Table 11. Percentage, within vessel tonnage class[1], of Atlantic cod otter-trawl landings (L)[2], vessel trips (T), and effort (DF)[3] from the Gulf of Maine (NAFO Division 5Y) accounted for by otter-trawl trips in which cod comprised 50% or more of the total trip catch, by weight ['directed trips'], 1965 - 1993.

	Class 2			Class 3			Class 4			Totals		
Year	L	T	DF	L	T	DF	L	T	DF	L	T	DF
1965	27.9	9.2	14.6	33.2	10.1	7.7	2.2	3.3	1.1	29.5	9.3	12.5
1966	20.0	5.2	<0.1	30.1	9.0	9.0	10.6	5.3	4.8	24.0	5.9	10.0
1967	36.6	10.7	30.2	51.3	18.1	21.9	0.9	1.0	0.5	43.9	12.3	25.7
1968	35.7	10.8	24.3	50.9	19.4	17.7	22.8	7.1	8.8	42.4	12.9	21.6
1969	46.8	17.5	42.4	48.2	21.8	19.5	18.9	8.1	11.3	45.0	18.4	33.7
1970	40.8	16.0	28.3	35.8	13.7	9.1	11.8	5.1	3.5	37.1	15.0	22.2
1971	35.4	14.1	25.8	31.3	15.2	8.4	25.3	3.4	5.7	33.4	13.9	20.0
1972	28.4	12.5	15.1	22.0	10.1	5.4	24.0	6.9	4.5	25.7	11.8	12.0
1973	18.8	7.6	9.7	8.2	4.4	2.3	0.5	1.4	0.4	14.1	6.7	7.4
1974	20.4	9.5	11.8	25.1	7.7	6.3	39.5	8.8	8.4	24.2	9.2	10.2
1975	33.7	12.3	23.7	40.0	15.2	12.8	21.2	5.6	3.8	35.8	12.7	19.5
1976	37.8	11.7	27.2	40.6	19.8	14.7	8.4	2.6	1.1	38.0	13.4	21.5
1977	36.4	10.5	31.9	46.8	19.5	13.6	12.9	3.4	1.0	40.4	12.8	23.3
1978	34.1	9.9	26.0	41.2	16.0	11.3	9.8	1.4	0.9	35.6	10.9	19.1
1979	29.9	9.7	19.8	38.9	18.6	11.8	9.7	2.2	0.9	32.4	11.4	16.0
1980	30.2	9.4	19.2	34.5	16.1	8.9	17.3	3.0	2.4	31.1	10.9	14.5
1981	42.6	10.5	32.3	37.4	13.5	8.3	13.3	3.4	1.5	37.6	11.1	20.4
1982	37.4	10.4	22.2	51.4	17.9	11.5	26.1	5.1	3.7	42.5	12.3	16.1
1983	40.3	12.2	25.4	53.5	23.9	12.7	16.9	5.4	1.6	43.8	15.6	16.9
1984	21.8	6.1	3.9	29.3	9.4	6.2	2.4	0.2	0.3	22.9	7.0	4.4
1985	24.3	6.4	5.5	29.6	9.2	5.4	13.5	2.8	2.5	24.6	7.1	4.9
1986	24.3	4.9	5.3	19.5	6.5	4.8	9.5	2.3	1.6	18.3	5.3	4.3
1987	22.4	4.0	3.8	13.6	4.0	3.2	7.8	2.5	1.5	14.6	3.9	3.1
1988	32.1	6.4	7.2	43.8	11.5	10.1	16.4	4.7	3.5	34.9	8.3	7.8
1989	53.2	13.5	14.8	54.7	21.4	21.1	32.6	15.8	14.9	49.2	16.7	17.7
1990	63.1	17.6	21.5	71.7	35.4	33.6	62.7	43.9	40.1	67.1	26.7	30.3
1991	68.7	27.3	29.3	71.1	37.1	39.6	73.0	56.9	55.7	71.3	33.0	39.2
1992	58.2	21.2	19.4	59.5	21.0	21.2	30.0	20.0	13.5	51.2	21.1	19.2
1993	37.6	13.0	10.8	54.0	17.3	16.4	33.0	15.5	13.2	45.1	14.9	14.1

[1] Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT.

[2] Metric tons, live weight.

[3] Effort expressed as days fished with trawl on bottom; derived by dividing hours fished with trawl on bottom by 24.

Table 12. Total and USA commercial landings, USA catch-per-unit of effort indices (CPUE: all cod trips), and derived effort indices for Gulf of Maine cod, 1965 - 1993.

Year	Total Landings (mt)	USA Landings (mt)	USA CPUE Index (All Cod Trips)	Total Calculated Days Fished	USA Calculated Days Fished
1965	3928	3780	0.6954	5649	5436
1966	4392	4008	0.8510	5161	4710
1967	5973	5676	1.4096	4237	4027
1968	6421	6360	1.1273	5696	5642
1969	8484	8157	1.4241	5957	5728
1970	8261	7812	0.8871	9312	8806
1971	7662	7380	0.8815	8692	8372
1972	6917	6776	0.6800	10172	9965
1973	6146	6069	0.6382	9630	9510
1974	7764	7639	1.0207	7607	7484
1975	9015	8903	1.0220	8821	8711
1976	10188	10172	1.0842	9397	9382
1977	12426	12426	1.2094	10275	10275
1978	12426	12426	0.9712	12794	12794
1979	11680	11680	0.9361	12477	12477
1980	13528	13528	0.8346	16209	16209
1981	12534	12534	0.8561	14641	14641
1982	13582	13582	0.8395	16179	16179
1983	13981	13981	0.8466	16514	16514
1984	10806	10806	0.5410	19974	19974
1985	10693	10693	0.5219	20489	20489
1986	9664	9664	0.4630	20873	20873
1987	7527	7527	0.3056	24630	24630
1988	7958	7958	0.3498	22750	22750
1989	10397	10397	0.5561	18696	18696
1990	15154	15154	1.0279	14743	14743
1991	17781	17781	1.1054	16086	16086
1992	10891	10891	0.5470	19910	19910
1993	8287	8287	0.4327	19152	19152

Table 13. Gulf of Maine cod GLM effort standardization.

SAS General Linear Models Procedure

Dependent Variable: LNCPUEDF

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	24	10042.42776453	418.43449019	271.01	0.0001
Error	22417	34610.87206235	1.54395646		
Corrected Total	22441	44653.29982688			

R-Square	C.V.	Root MSE	LNCPUEDF Mean
0.224898	-116.8327	1.24256045	-1.06353847

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	10	4172.47634712	417.24763471	270.25	0.0001
AREA	4	213.43028101	53.35757025	34.56	0.0001
QTR	3	1091.33076950	363.77692317	235.61	0.0001
TONCLASS	4	2804.09441832	701.02360458	454.04	0.0001
DEPTHCD	3	1761.09594858	587.03198286	380.21	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	10	3864.47552921	386.44755292	250.30	0.0001
AREA	4	337.52113256	84.38028314	54.65	0.0001
QTR	3	1077.53586173	359.17862058	232.64	0.0001
TONCLASS	4	3365.93344569	841.48336142	545.02	0.0001
DEPTHCD	3	1761.09594858	587.03198286	380.21	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate	Retransformed Estimate
INTERCEPT		-0.966438423 B	-22.51	0.0001	0.04293803	
AREA	511	0.352862172 B	6.04	0.0001	0.05840734	1.425565
	512	0.093390087 B	2.64	0.0083	0.03535865	1.098576
	513	0.282590501 B	11.13	0.0001	0.02540134	1.326990
	515	-0.026414709 B	-0.84	0.4026	0.03155861	0.974416
	514	0.000000000 B	.	.	.	1.000000
QTR	1	-0.450275482 B	-17.99	0.0001	0.02503570	0.637652
	3	-0.555648751 B	-23.76	0.0001	0.02338944	0.573857
	4	-0.471084150 B	-20.69	0.0001	0.02276910	0.624487
	2	0.000000000 B	.	.	.	1.000000
TONCLASS	31	0.470024146 B	18.66	0.0001	0.02519506	1.600541
	32	0.854568967 B	33.24	0.0001	0.02571061	2.351138
	33	0.896470299 B	32.09	0.0001	0.02793882	2.451894
	41	1.301746565 B	43.24	0.0001	0.03010851	3.677377
	25	0.000000000 B	.	.	.	1.000000
DEPTHCD	1	0.593978838 B	18.13	0.0001	0.03275947	1.812153
	2	0.324741394 B	12.86	0.0001	0.02525790	1.384114
	4	-0.636948746 B	-24.01	0.0001	0.02652370	0.529090
	3	0.000000000 B	.	.	.	1.000000

Table 14. Nominal and standardized (GLM) Gulf of Maine cod landings (mt), effort (days fished) and landings per day fished (LPUE) for the otter trawl effort standardization fleet, 1982-1993.

		Nominal		Standardized	
Year	Landings (mt)	Effort	LPUE	Effort	LPUE
1982	3395	3158	1.075	4953	0.686
1983	3698	3791	0.975	5782	0.640
1984	2423	3798	0.638	5495	0.441
1985	3012	5294	0.569	8489	0.355
1986	2794	5568	0.502	8745	0.320
1987	1708	5100	0.335	7836	0.218
1988	2060	4753	0.433	7994	0.258
1989	2316	3524	0.657	6125	0.378
1990	4916	4053	1.213	7663	0.641
1991	5432	4737	1.147	8829	0.615
1992	2777	4978	0.558	8003	0.347
1993	2284	4727	0.483	6879	0.332

Table 15. Standardized stratified mean catch per tow in numbers and weight (kg) for Atlantic cod from NEFSC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine (Strata 26-30 and 36-40), 1963 - 1994. [a,b]

	Gulf of Maine [c]			
	Spring		Autumn	
Year	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	5.92	17.9
1964	-	-	4.00	2208
1965	-	-	4.49	12.0
1966	-	-	3.78	12.9
1967	-	-	2.56	9.2
1968	5.44	17.9	4.34	19.4
1969	3.25	13.2	2.76	15.4
1970	2.21	11.1	4.90	16.4
1971	1.43	7.0	4.37	16.5
1972	2.06	8.0	9.31	13.0
1973	7.54	18.8	4.46	8.7
1974	2.91	7.4	4.33	9.0
1975	2.51	6.0	6.15	8.6
1976	2.78	7.6	2.15	6.7
1977	3.88	8.5	3.08	10.2
1978	2.06	7.7	5.75	12.9
1979	4.27	9.5	3.49	17.5
1980	2.15	6.2	7.04	14.2
1981	4.86	10.8	2.42	8.1
1982	3.75	8.6	7.77	16.1
1983	3.91	10.5	4.22	8.8
1984	3.40	5.8	2.42	8.8
1985	2.52	7.7	2.92	8.5
1986	1.96	3.6	1.95	5.1
1987	1.68	3.0	2.98	3.4
1988	3.13	3.3	5.90	6.6
1989	2.26	2.5	4.65	4.6
1990	2.36	3.1	2.99	4.9
1991	2.39	2.9	1.25	2.8
1992	2.41	8.7	1.43	2.4
1993	2.50	5.9	1.23	1.0
1994	1.27	2.4	----	---

[a] During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portugeuse polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFC 1991).

[b] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these differences.

[c] In the Gulf of Maine, spring surveys during 1980-1982, 1989-1991 and 1994, and autumn surveys during 1977-1978, 1980, 1989-1991 and 1993 were accomplished with the R/V DELAWARE II; in all other years, the surveys were accomplished using the R/V ALBATROSS IV. Adjustments have been made to the R/V DELAWARE II catch per tow data to standardize these to R/V ALBTATROSS IV equivalents. Conversion coefficients 0.79 (number) and 0.67 (weight) were used in this standardization (NEFC 1991).

Table 16. Estimates of instantaneous total mortality (Z) and fishing mortality (F)[1] for Gulf of Maine Atlantic cod for eight time periods, 1964 - 1993, derived from NEFSC offshore spring and autumn bottom trawl survey data.[2]

Time Period	Gulf of Maine					
	Spring		Autumn		Geometric Mean	
	Z	F	Z	F	Z	F
1964-1967	-	-	0.39	0.19	0.39	0.19
1968-1972	0.37[3]	0.17	0.43[7]	0.23	0.40	0.20
1973-1976	0.35[4]	0.15	0.45	0.25	0.40	0.20
1977-1981	0.52	0.32	0.57[8]	0.37	0.54	0.34
1982-1984	0.73	0.53	0.78	0.58	0.75	0.55
1985-1987	0.58[5]	0.38	1.05	0.85	0.78	0.58
1988-1990	1.24	1.04	0.72	0.61	0.94	0.74
1991-1993	1.02[6]	0.82	1.18	0.98	1.10	0.90

[1] Instantaneous natural mortality (M) assumed to be 0.20.

[2] Estimates derived from:

Spring: ln (Σ age 4+ for year i to j/ Σ age 5+ for years i+1 to j+1).
Autumn: ln (Σ age 3+ for years i-1 to j-1/ Σ age 4+ for years i to j).

[3] Excludes spring 1972-1973 data (4+/5+) since these gave large negative Z value.

[4] Excludes spring 1973-1974 data (4+/5+) since these gave unreasonably high Z value.

[5] Excludes spring 1985-1986 data (4+/5+) since these gave unreasonably high Z value.

[6] Excludes spring 1991-1992 data (4+/5+) since these gave unreasonably low Z value.

[7] Excludes autumn 1967-1968 data (3+/4+) since these gave large negative Z value.

[8] Excludes autumn 1976-1977 data (3+/4+) since these gave large negative Z value.

Table 17. Summary statistics of the base, alternative, and final ADAPT VPA calibration for Gulf of Maine cod; terminal year 1993.

ADAPT Run Number 291 1994 10 13 13 54 32
COD: GULF OF MAINE STOCK
GMCOD94 - 8+ GROUP; ALL INDICES UNWEIGHTED, NO TIME TAPERED WEIGHTING

1994 N	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.	1993 F	Estimate
N 2	4.20334E3	1.27682E3	3.29203E0	0.30	F 2	0.02
N 3	3.48325E3	8.09347E2	4.30378E0	0.23	F 3	0.73
N 4	1.25882E3	3.42497E2	3.67541E0	0.27	F 4	1.21
N 5	2.45215E2	8.42669E1	2.90999E0	0.34	F 5	0.64
N 6	1.31386E2	5.02920E1	2.61247E0	0.38	F 6	0.92
					F 7	0.92
					F 8+	0.92

ADAPT Run Number 328 1994 10 17 17 36 35
COD: GULF OF MAINE STOCK
GMCOD94 - 8+ GROUP; NO COMMERCIAL INDICES; ELSE THE SAME AS RUN 291 IN WP 1.

1994 N	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.	1993 F	Estimate
N 2	4.18515E3	1.39773E3	2.99425E0	0.33	F 2	0.02
N 3	3.46780E3	8.86014E2	3.91393E0	0.26	F 3	0.76
N 4	1.17489E3	3.74733E2	3.13528E0	0.32	F 4	1.30
N 5	2.16457E2	9.15470E1	2.36444E0	0.42	F 5	0.61
N 6	1.38454E2	6.84113E1	2.02385E0	0.49	F 6	0.96
					F 7	0.96
					F 8+	0.96

ADAPT Run Number 329 1994 10 17 18 12 38
COD: GULF OF MAINE STOCK
GMCOD94 - 8+ GROUP; ALL INDICES AS IN RUN 291 PLUS #20 MASS FALL3
ALL MASS INDICES REVISED AS PER CADRIN NDSC WP 10/18/94

1994 N	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.	1993 F	Estimate
N 2	3.91102E3	1.32800E3	2.94505E0	0.34	F 2	0.02
N 3	3.86923E3	9.38559E2	4.12252E0	0.24	F 3	0.74
N 4	1.22424E3	3.66153E2	3.34352E0	0.30	F 4	1.15
N 5	2.69231E2	1.00742E2	2.67247E0	0.37	F 5	0.60
N 6	1.43170E2	5.97292E1	2.39699E0	0.42	F 6	0.87
					F 7	0.87
					F 8+	0.87

ADAPT Run Number 334 1994 10 18 11 13 11
COD: GULF OF MAINE STOCK
GMCOD94 - 7+ GROUP; ESTIMATE AGE 4 F FROM PR
NO EST OF AGE 5 N; ONLY FULLY RECR AGE 5 F ESTIMATED DIRECTLY

1994 N	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.	1993 F	Estimate
N 2	4.21563E3	1.29927E3	3.24462E0	0.31	F 2	0.02
N 3	3.49331E3	8.23544E2	4.24179E0	0.24	F 3	0.73
N 4	1.26180E3	3.48188E2	3.62391E0	0.28	F 4	0.96
N 6	7.18931E1	1.88437E1	3.81524E0	0.26	F 5	0.96
					F 6	0.96
					F 7+	0.96

ADAPT Run Number 332 1994 10 18 11 0 8
COD: GULF OF MAINE STOCK
GMCOD94 - 7+ GROUP; ELSE SAME AS RUN 291

1994 N	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.	1993 F	Estimate
N 2	4.20596E3	1.28877E3	3.26355E0	0.31	F 2	0.02
N 3	3.48446E3	8.16696E2	4.26653E0	0.23	F 3	0.73
N 4	1.25793E3	3.45296E2	3.64306E0	0.27	F 4	1.22
N 5	2.42140E2	8.41553E1	2.87730E0	0.35	F 5	0.63
N 6	1.31816E2	5.07636E1	2.59666E0	0.39	F 6	0.93

Table 18. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F) and spawning stock biomass (tons) for Gulf of Maine cod derived from virtual population analysis (VPA) calibrated using the ADAPT procedure, 1982-1993.

STOCK NUMBERS (Jan 1) in thousands - GMCOD94

■	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1 ■	6129	5534	7742	4915	7413	9970	21715	3467	3168	5166	5301	5137	n/a
2 ■	9108	5018	4531	6339	4024	6070	8163	17778	2838	2594	4230	4340	4206
3 ■	4328	6208	3325	3306	4822	3219	4774	6538	14251	2138	1812	3180	3484
4 ■	2666	2066	2950	1600	1399	1990	2097	2603	3921	8568	906	1004	1258
5 ■	1661	1149	734	1058	413	410	625	855	815	1342	3250	304	242
6 ■	166	787	363	206	296	112	85	145	293	279	329	835	132
7+■	547	284	250	214	156	132	58	98	182	152	134	65	291
1+■	24606	21046	19896	17638	18524	21902	37517	31484	25469	20239	15962	14864	----
2+■	18477	15512	12154	12723	11110	11932	15802	28017	22301	15073	10661	9727	9613

FISHING MORTALITY - GMCOD94

■	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1 ■	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 ■	0.18	0.21	0.12	0.07	0.02	0.04	0.02	0.02	0.08	0.16	0.09	0.02
3 ■	0.54	0.54	0.53	0.66	0.69	0.23	0.41	0.31	0.31	0.66	0.39	0.73
4 ■	0.64	0.83	0.83	1.15	1.03	0.96	0.70	0.96	0.87	0.77	0.89	1.22
5 ■	0.55	0.95	1.07	1.07	1.10	1.37	1.26	0.87	0.87	1.21	1.16	0.63
6 ■	0.61	0.90	0.89	1.16	1.08	1.05	0.82	0.96	0.89	0.84	1.13	0.93
7+■	0.61	0.90	0.89	1.16	1.08	1.05	0.82	0.96	0.89	0.84	1.13	0.93
4+■	0.59	0.89	0.95	1.11	1.07	1.17	0.98	0.91	0.87	0.99	1.03	0.93

SSB AT THE START OF THE SPAWNING SEASON - males & females (MT)

■	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1 ■	328	297	399	142	214	292	642	111	221	310	346	336
2 ■	2143	1247	1141	3096	2016	3043	4034	8713	638	591	1137	1083
3 ■	3185	4634	2503	3871	6013	4219	6442	8559	10269	1297	1307	2503
4 ■	4821	3105	4650	2781	2576	4029	3650	5089	5334	12174	1261	1410
5 ■	6070	2972	1738	2983	1205	1184	2018	2189	2290	3059	6755	854
6 ■	823	3496	1429	739	1246	511	409	598	1302	1282	1174	2948
7+■	5407	2309	2127	1666	1290	1103	566	986	2083	1459	1140	593
1+■	22776	18060	13987	15278	14558	14382	17761	26246	22138	20172	13120	9727
2+■	22448	17763	13588	15136	14344	14090	17119	26135	21917	19862	12774	9391

PERCENT MATURE (females) - GMCOD94

■	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1 ■	7	7	7	4	4	4	4	4	9	9	9	9
2 ■	26	26	26	48	48	48	48	48	24	24	24	24
3 ■	61	61	61	95	95	95	95	95	54	54	54	54
4 ■	88	88	88	100	100	100	100	100	81	81	81	81
5 ■	97	97	97	100	100	100	100	100	94	94	94	94
6 ■	100	100	100	100	100	100	100	100	98	98	98	98
7+■	100	100	100	100	100	100	100	100	100	100	100	100

Table 19. Results of retrospective analysis of Gulf of Maine cod VPA based on final ADAPT formulation.

Retrospective Analysis - Gulf of Maine Cod - Fishing Mortality (Avg F 4-5,u)

Term Yr	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
88	0.59	0.89	0.95	1.12	1.07	1.21	1.04					
89	0.59	0.89	0.95	1.12	1.08	1.21	1.08	1.22				
90	0.59	0.89	0.95	1.11	1.07	1.18	1.01	1.00	1.05			
91	0.59	0.89	0.95	1.11	1.07	1.17	0.99	0.94	0.93	1.08		
92	0.59	0.89	0.95	1.11	1.07	1.17	0.98	0.91	0.87	0.98	1.07	
93	0.59	0.89	0.95	1.11	1.07	1.17	0.98	0.91	0.87	0.99	1.03	0.93

Retrospective Analysis - Gulf of Maine Cod - Spawning Stock Biomass

Term Yr	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
88	22771	18052	13974	15250	14262	13451	16727					
89	22770	18050	13966	15209	14291	13724	17015	26515				
90	22774	18057	13981	15255	14481	14131	17262	25515	21412			
91	22776	18059	13985	15271	14535	14300	17533	25476	21324	18857		
92	22776	18060	13987	15278	14559	14385	17774	26249	22145	20170	13267	
93	22776	18060	13987	15278	14558	14382	17761	26246	22138	20172	13120	9727

Retrospective Analysis - Gulf of Maine Cod - Recruitment (Age 2)

Term Yr	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
88	9102	5021	4505	6397	3488	5206	9387	22272					
89	9103	5014	4515	6300	3729	5650	8735	19906	4818				
90	9106	5016	4527	6320	3965	5818	8075	17722	3995	2830			
91	9107	5017	4530	6332	4009	5981	8075	16798	3541	2677	4019		
92	9108	5018	4531	6339	4027	6068	8187	17729	2780	2742	4473	5089	
93	9108	5018	4531	6339	4024	6070	8163	17778	2838	2594	4230	4340	4206

Table 20. Yield and spawning stock biomass per recruit estimates and input data for Gulf of Maine cod.

```
The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
 PC Ver.1.2 [Method of Thompson and Bell (1934)] 1-Jan-1992
          Run Date:  9-11-1994;  Time: 13:54:33.08
GULF OF MAINE COD (5Y) -  1993 UPDATED AVE WTS, FPAT AND MAT VECTORS

Proportion of F before spawning:  .1667
Proportion of M before spawning:  .1667
Natural Mortality is Constant at:  .200
Initial age is:  1; Last age is: 10
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
==> d:\assess\gmcod\yrcodgma.dat
```

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Stock
1	.0000	1.0000	.0900	.500	.749
2	.0530	1.0000	.2400	1.257	1.061
3	.4210	1.0000	.5400	1.768	1.481
4	.8740	1.0000	.8100	2.503	2.083
5	1.0000	1.0000	.9400	3.955	3.212
6	1.0000	1.0000	1.0000	6.532	4.978
7	1.0000	1.0000	1.0000	9.985	7.813
8	1.0000	1.0000	1.0000	12.603	11.105
9	1.0000	1.0000	1.0000	14.670	13.261
10+	1.0000	1.0000	1.0000	16.000	16.000

```
Summary of Yield per Recruit Analysis for:
GULF OF MAINE COD (5Y) -  1993 UPDATED AVE WTS, FPAT AND MAT VECTORS

 Slope of the Yield/Recruit Curve at F=0.00: -->   26.8273
   F level at slope=1/10 of the above slope (F0.1): ----->    .158
     Yield/Recruit corresponding to F0.1: ----->    1.6779
   F level to produce Maximum Yield/Recruit (Fmax): ----->    .267
     Yield/Recruit corresponding to Fmax: ----->    1.7927
   F level at 20 % of Max Spawning Potential (F20): ----->    .345
     SSB/Recruit corresponding to F20: -------->    5.2776
```

Listing of Yield per Recruit Results for:
GULF OF MAINE COD (5Y) - 1993 UPDATED AVE WTS, FPAT AND MAT VECTORS

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.00	.00000	.00000	5.5167	29.3875	3.4286	26.3906	100.00
	.09	.18990	1.37603	4.5716	17.3945	2.4926	14.5942	55.30
F0.1	.16	.26531	1.67788	4.1975	13.2111	2.1245	10.5158	39.85
	.19	.28967	1.73678	4.0769	11.9622	2.0064	9.3048	35.26
Fmax	.27	.34508	1.79274	3.8033	9.3520	1.7396	6.7889	25.72
	.28	.35173	1.79193	3.7706	9.0627	1.7078	6.5117	24.67
F20%	.35	.38332	1.76604	3.6153	7.7691	1.5578	5.2776	20.00
	.37	.39442	1.74852	3.5608	7.3473	1.5054	4.8775	18.48
	.47	.42583	1.67723	3.4072	6.2548	1.3587	3.8485	14.58
	.56	.45007	1.60353	3.2893	5.5181	1.2473	3.1625	11.98
	.65	.46947	1.53622	3.1955	4.9977	1.1596	2.6834	10.17
	.74	.48542	1.47768	3.1186	4.6154	1.0885	2.3356	8.85
	.84	.49885	1.42781	3.0543	4.3251	1.0296	2.0746	7.86
	.93	.51036	1.38569	2.9995	4.0983	.9799	1.8731	7.10
	1.02	.52036	1.35016	2.9520	3.9168	.9374	1.7135	6.49
	1.12	.52917	1.32013	2.9103	3.7682	.9004	1.5845	6.00
	1.21	.53702	1.29465	2.8734	3.6445	.8680	1.4781	5.60
	1.30	.54407	1.27291	2.8404	3.5396	.8392	1.3890	5.26
	1.40	.55046	1.25426	2.8106	3.4496	.8135	1.3133	4.98
	1.49	.55628	1.23816	2.7835	3.3712	.7903	1.2481	4.73
	1.58	.56163	1.22416	2.7587	3.3023	.7693	1.1913	4.51
	1.67	.56656	1.21193	2.7359	3.2412	.7502	1.1414	4.33
	1.77	.57113	1.20116	2.7149	3.1865	.7326	1.0972	4.16
	1.86	.57539	1.19163	2.6954	3.1371	.7164	1.0576	4.01

Table 21. Stock biomass and catch projections, starting conditions and input data for Gulf of Maine cod.

Input for Projections:

Number of Years: 4; Initial Year: 1994; Final Year: 1997
Number of Ages : 6; Age at Recruitment: 2; Last Age: 7
Natural Mortality is assumed Constant over time at: .200
Proportion of F before spawning: .1667
Proportion of M before spawning: .1667
Last age is a PLUS group;

Age-specific Input data for Projection # 1

Age	Stock Size in 1994	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Stock
2	4206.	.0530	1.0000	.2400	1.257	1.061
3	3484.	.4210	1.0000	.5400	1.768	1.481
4	1258.	.8740	1.0000	.8100	2.503	2.083
5	242.	1.0000	1.0000	.9400	3.955	3.212
6	132.	1.0000	1.0000	1.0000	6.532	4.978
7+	291.	1.0000	1.0000	1.0000	12.000	11.000

Projections for 1995-1997; F(94)=0.93, Basis: Status quo 1993 point estimate.
Recruitment (age 2) of the 1993-1995 year classes estimated from stochastic projections of SSB based on R/S ratios of the 1980-1991 year classes.
SSB was estimated to be 9,400 t in 1993

1994			1995			1996		1997
F	Landings	SSB	F	Landings	SSB	Landings	SSB	SSB
0.93	7822	8146	F_{max} =0.27	2487	8098	3285	11120	14004
0.93	7822	8146	$F_{20\%}$=0.35	3135	8011	3923	10394	12405
0.93	7822	8146	$_{50\%}F_{SQ}$ =0.47	4041	7881	4667	9408	10385
0.93	7822	8146	$_{90\%}F_{SQ}$ =0.84	6392	7493	5841	6963	6198
0.93	7822	8146	F_{SQ} =0.93	6878	7402	5958	6484	5509

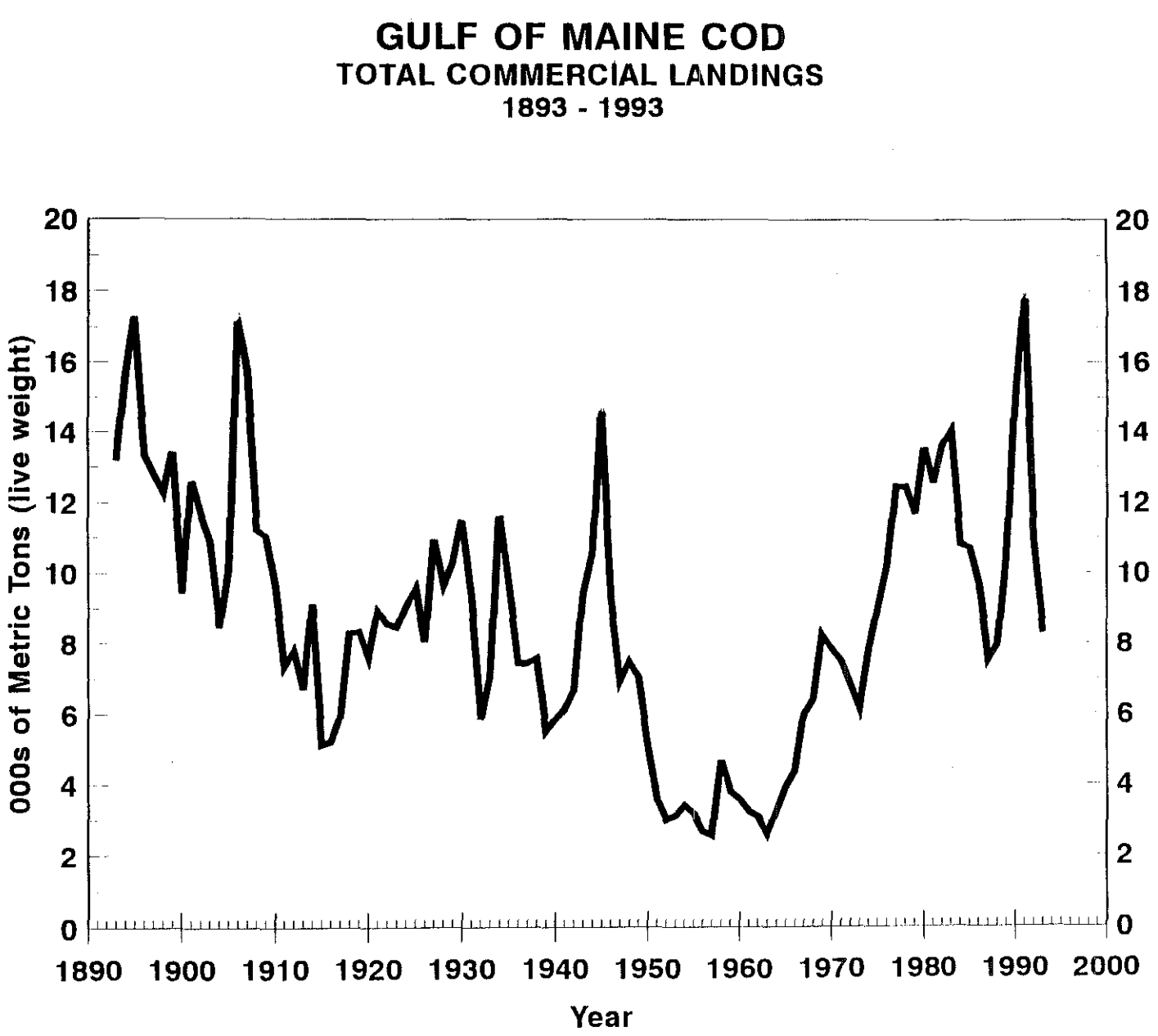


Figure 1. Total commercial landings of Gulf of Maine cod (Division 5Y), 1893-1993.

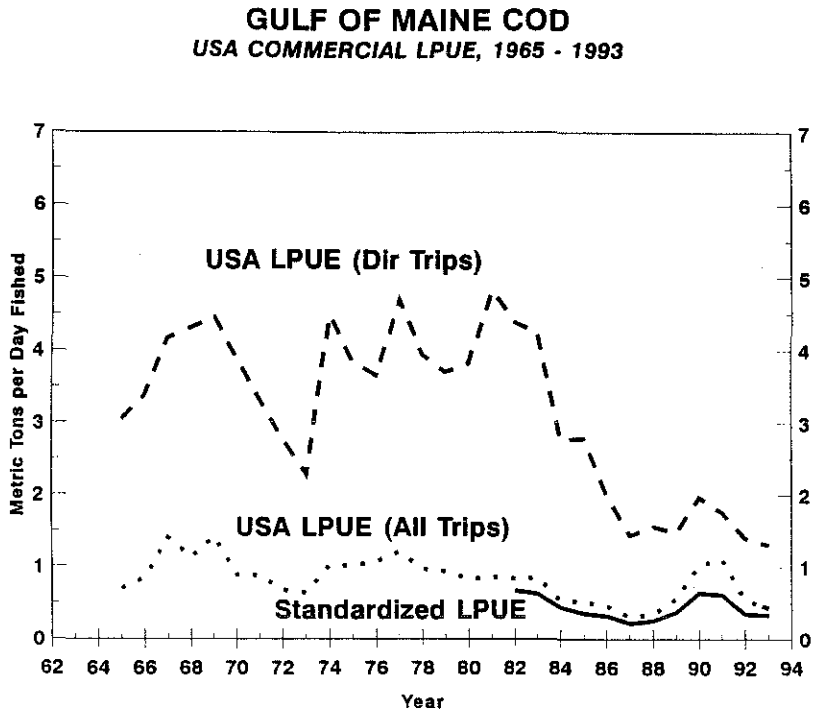


Figure 2. Trends in USA LPUE (landings per day fished) of Gulf of Maine cod. The 1965-1993 indices are based on all otter trawl trips landing cod (All trips) and on otter trawl trips in which cod constituted 50% or more of the trip landings by weight (Dir trips). A standardized LPUE series from 1982-1993 based on a GLM incorporating year, tonnage class, area, quarter and depth is also included.

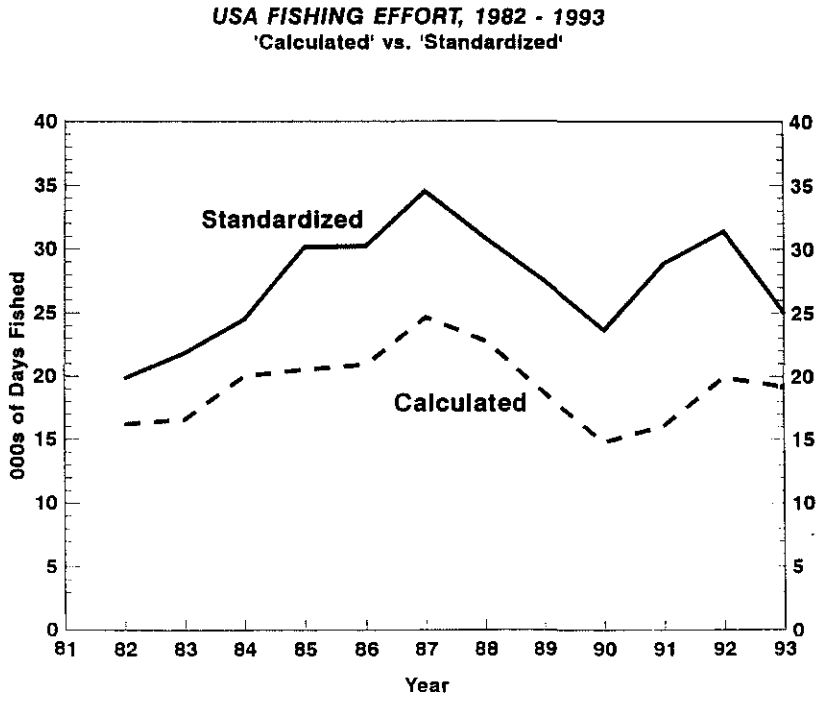


Figure 3. Trends in USA fishing effort (days fished) on Gulf of Maine cod, 1982-1993. Results are based on all otter trawl trips landing cod. A standardized effort series based on a GLM incorporating year, tonnage class, area, quarter and depth is also included.

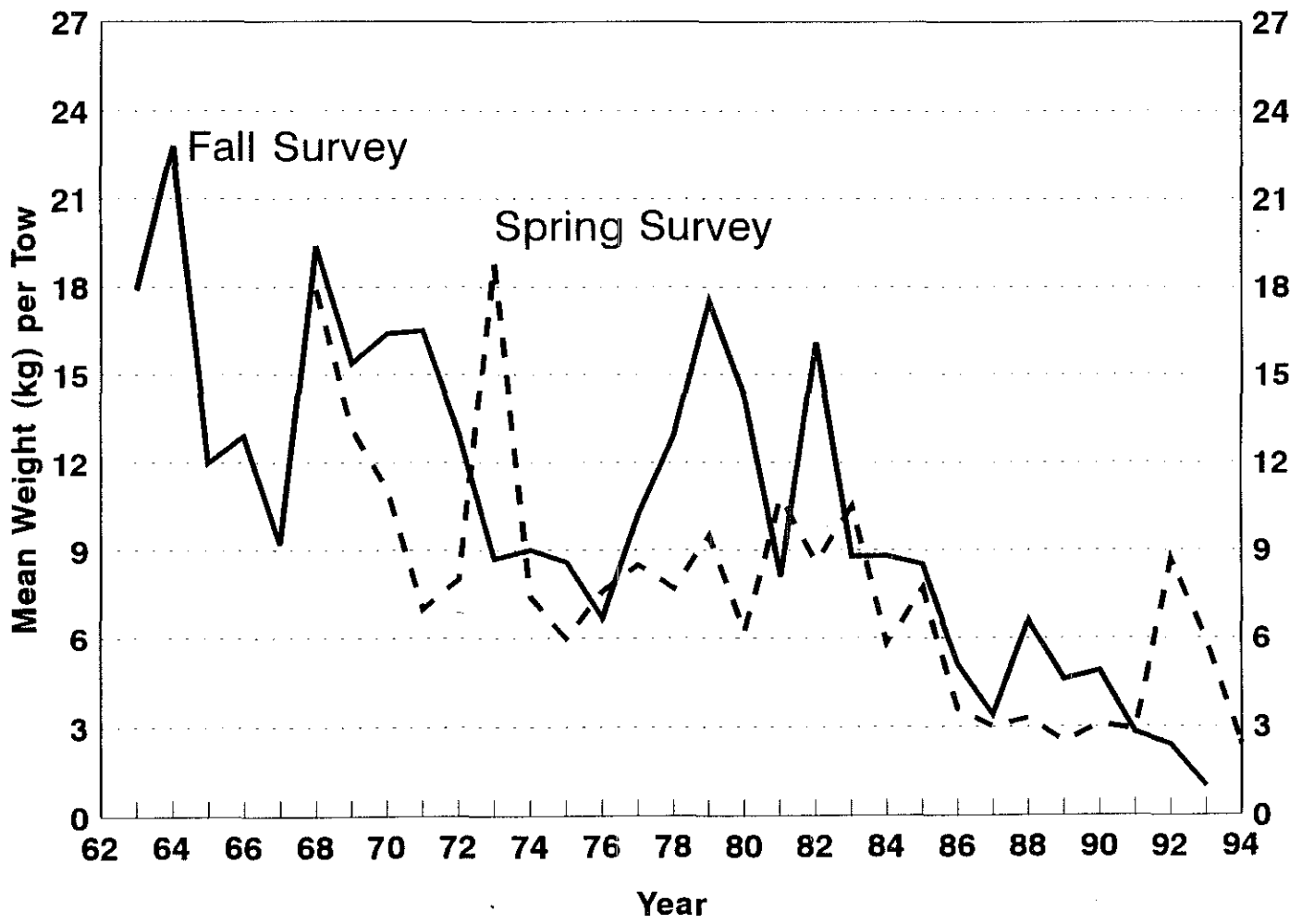


Figure 4. Standardized stratified mean catch (kg) per tow of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys in the Gulf of Maine, 1963-1994.

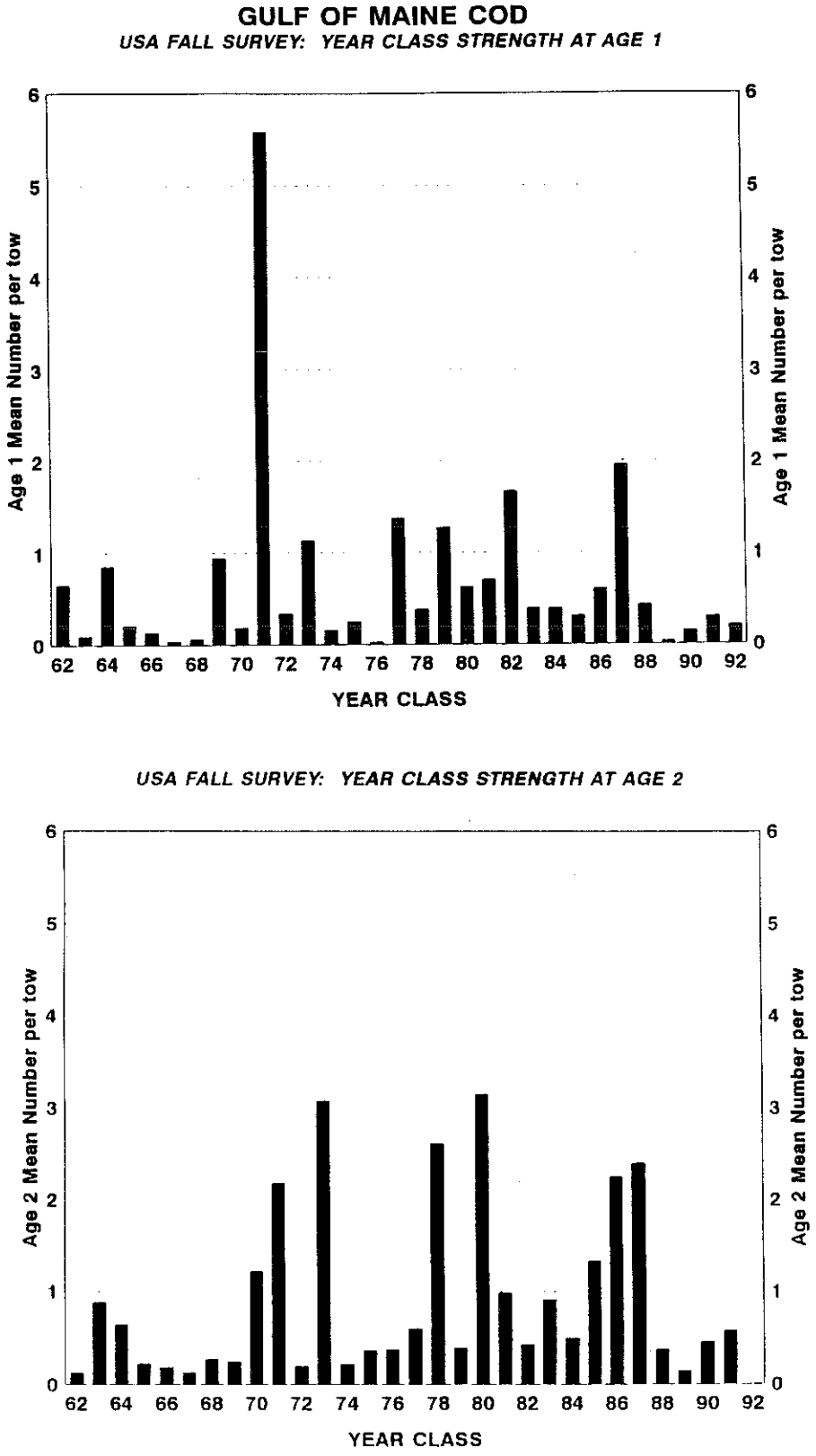


Figure 5. Relative year class strengths of Gulf of Maine cod at (a) age 1 and (b) age 2 based on standardized catch (number) per tow indices from NEFSC autumn research vessel bottom trawl surveys, 1963-1993.

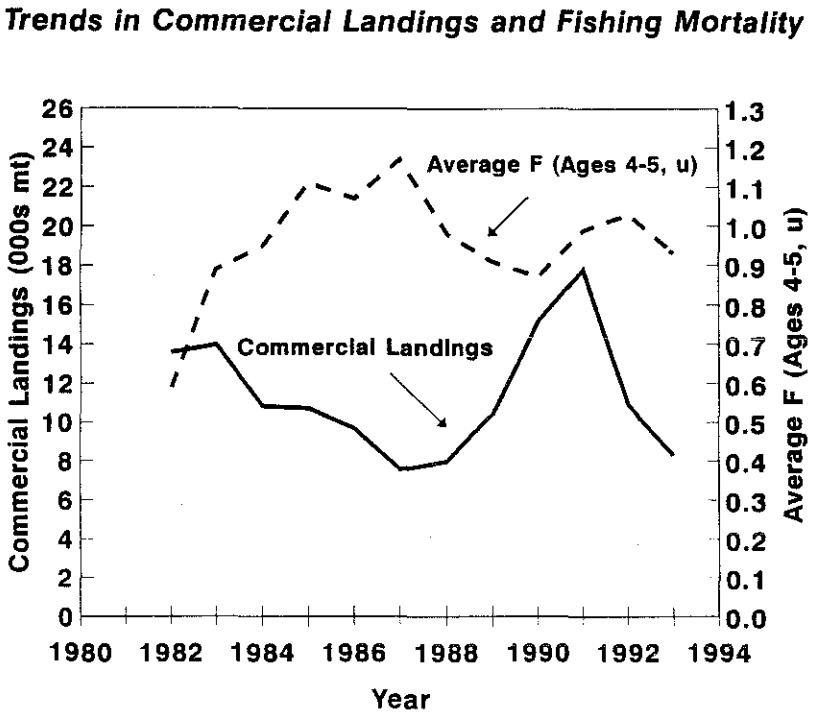


Figure 6. Trends in total commercial landings and fishing mortality for Gulf of Maine cod, 1982-1993.

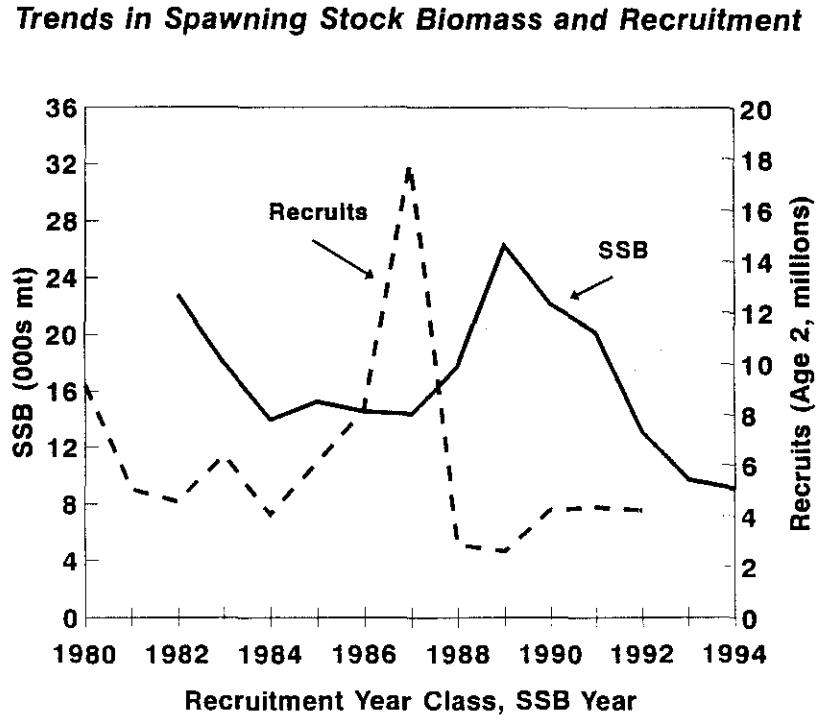


Figure 7. Trends in spawning stock biomass and recruitment for Gulf of Maine cod.

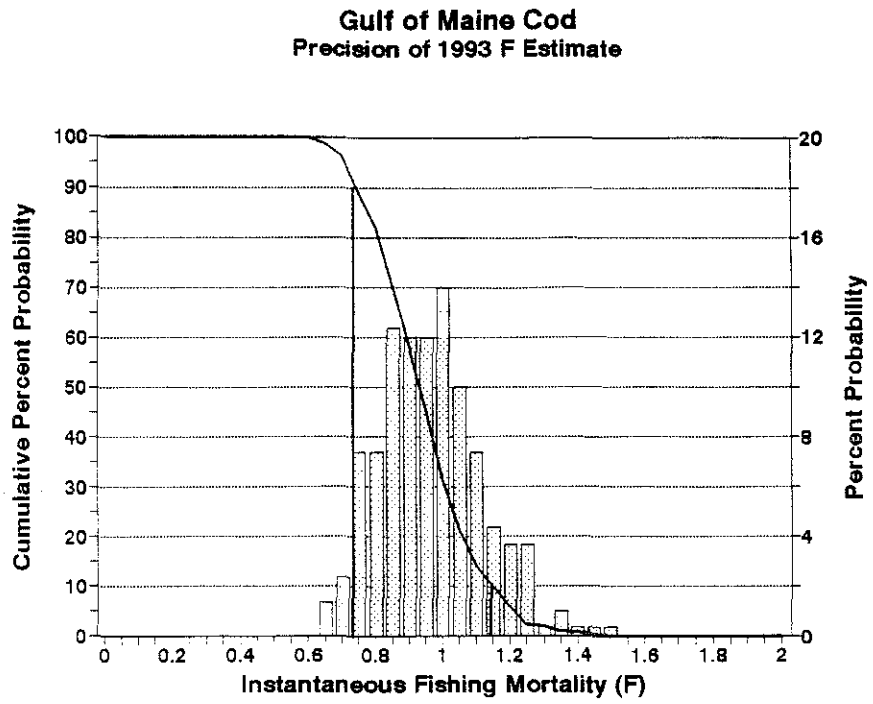


Figure 8. Precision of the estimates of the instantaneous rate of fishing mortality (F) on the fully recruited ages (ages 4+) in 1993 for Gulf of Maine cod. The vertical bars display both the range of the estimator and the probability of individual values within the range. The solid line gives the probability that F is greater than any selected value on the X-axis. The precision estimates were derived from 300 bootstrap replications of the final ADAPT VPA formulation.

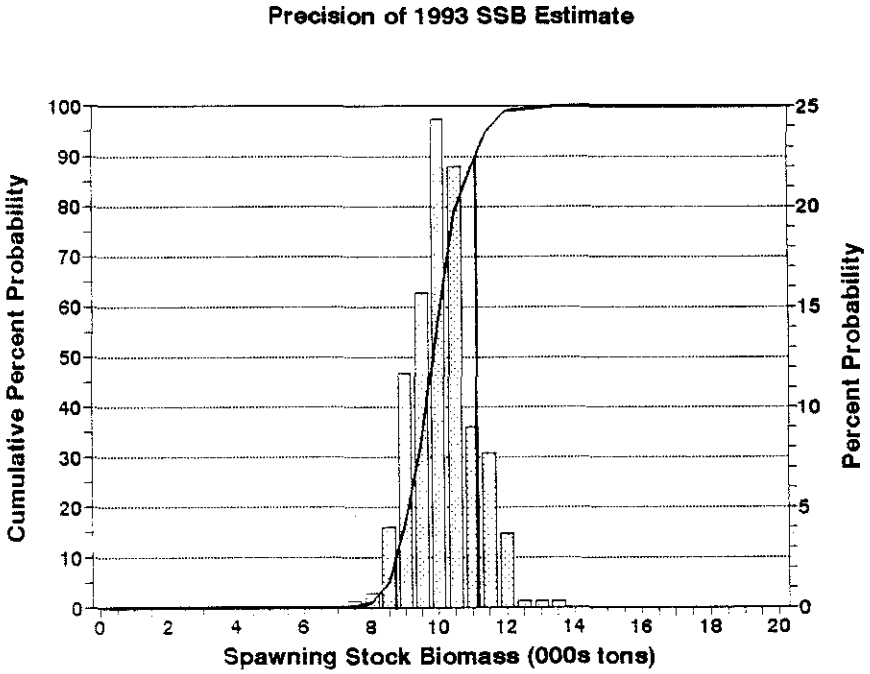
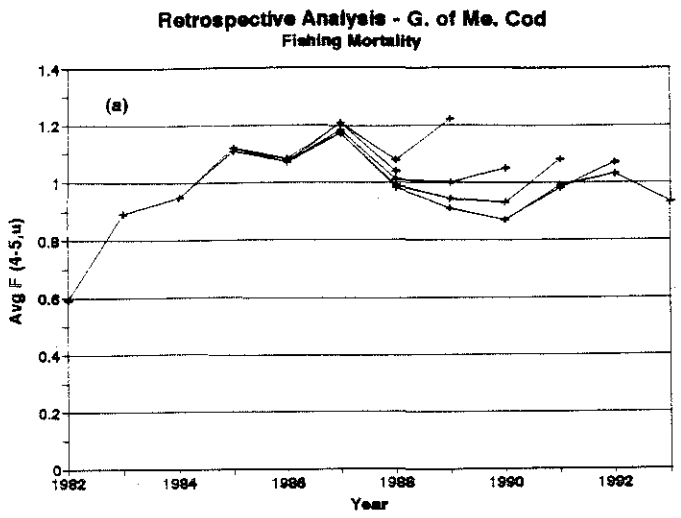
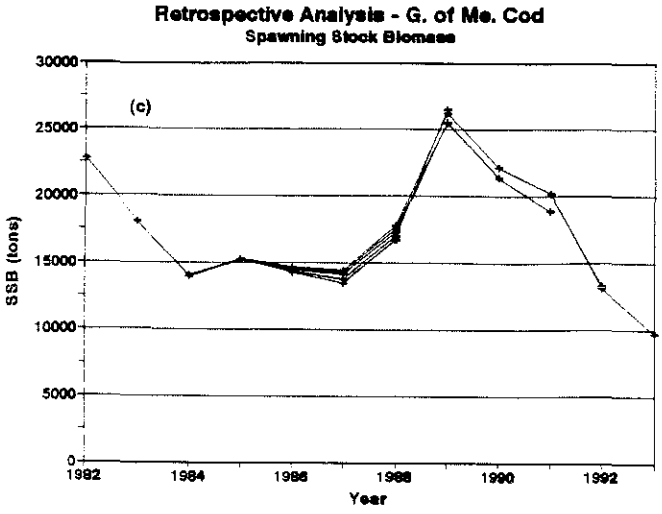


Figure 9. Precision of the estimates of spawning stock biomass (SSB) at the beginning of the spawning season (March 1) for Gulf of Maine cod, 1993. The vertical bars display both the range of the estimator and the probability of individual values within the range. The solid line gives the probability that SSB is less than any selected value on the X-axis. The precision estimates were derived from 300 bootstrap replications of the final ADAPT VPA formulation.





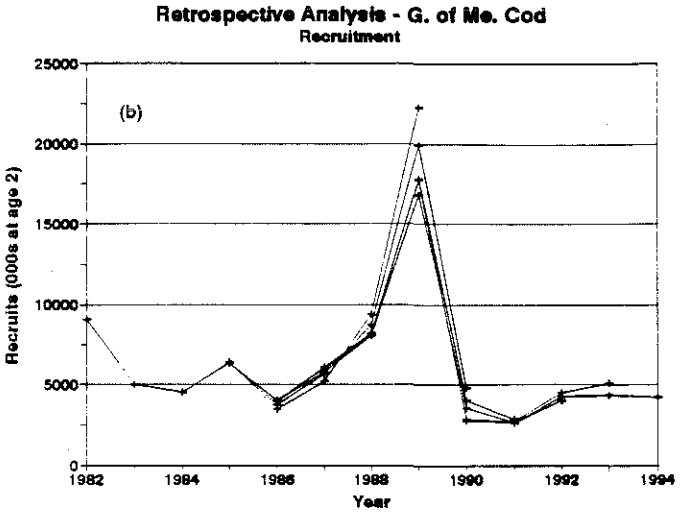


Figure 10. Retrospective analysis of Gulf of Maine cod VPA based on final ADAPT formulation.

a) Average (4-5,unweighted) fishing mortality

b) Recruits (age 2)

c) Spawning stock biomass

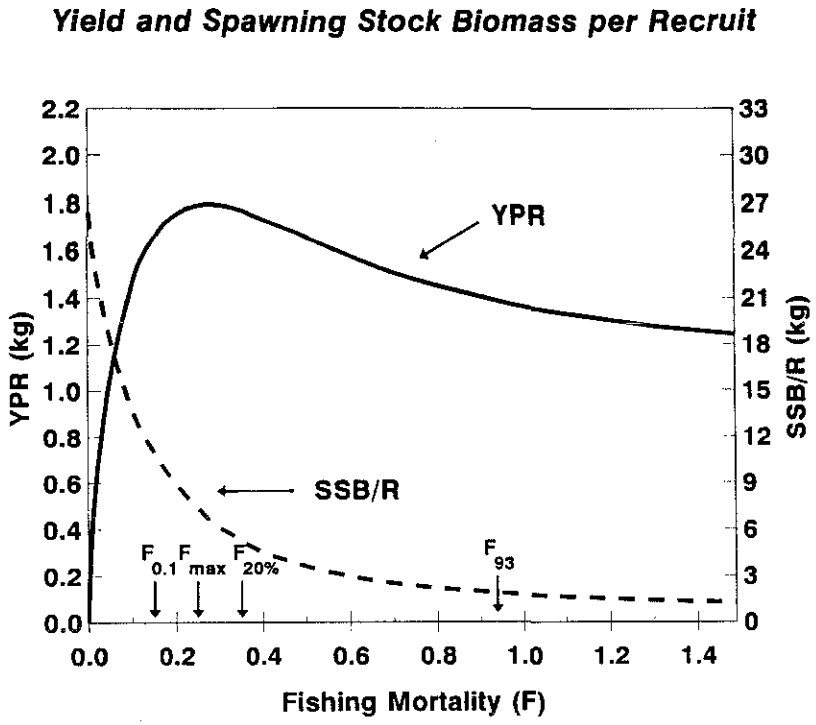


Figure 11. Yield per recruit (YPR) and spawning stock biomass per recruit (SSB/R) for Gulf of Maine cod.

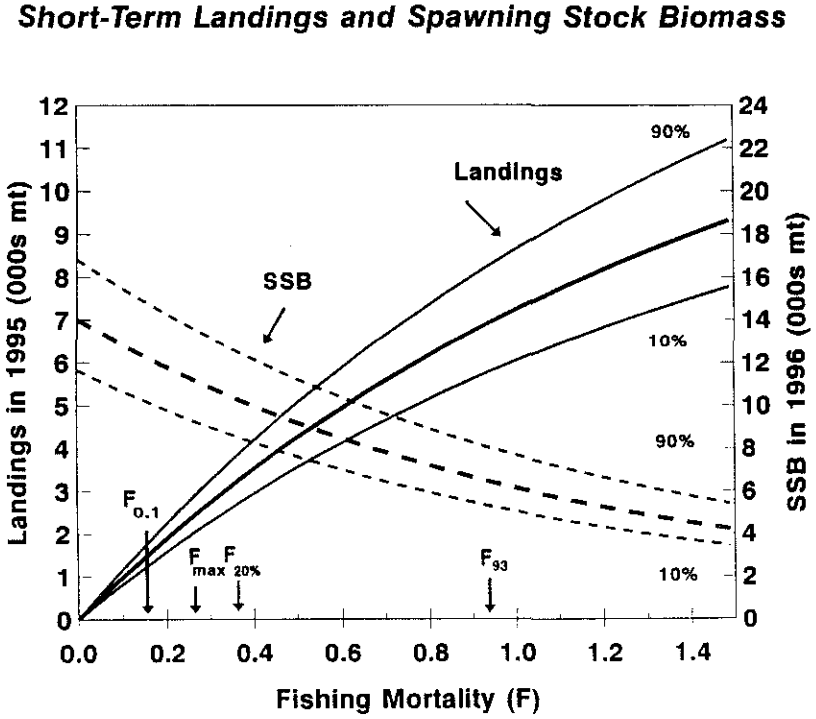


Figure 12. Predicted catches in 1995 and spawning stock biomasses in 1996 of Gulf of Maine cod over a range of fishing mortalities in 1995 from F=0 to F=1.6.

Gulf of Maine Cod

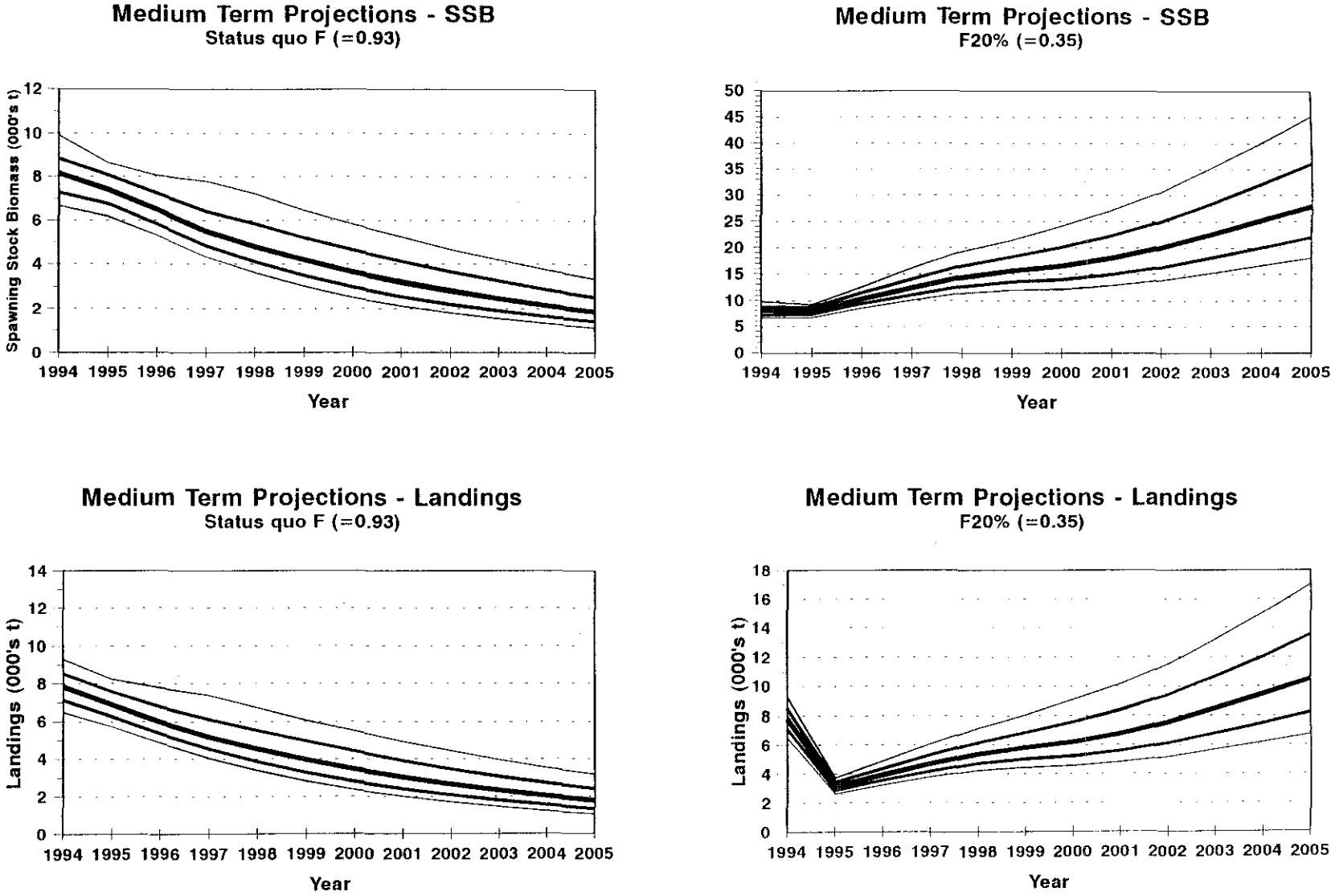


Figure 13. Medium-term stochastic projections of spawning stock biomass and landings for Gulf of Maine cod at status quo fishing mortality (0.93) and $F_{20\%}$ (0.35). Lines show the 10, 25, 50, 75 and 90th percentiles. The thickness of the line indicates the probability level; the thicker the line the more likely the outcome.

Appendix 1. Age-specific bottom trawl survey abundance indices for Gulf of Maine cod.

Table 1. Stratified mean catch per tow at age (numbers) of Atlantic cod in NEFC offshore spring and autumn bottom trawl surveys in the Gulf of Maine, 1963 - 1993.

Table 2. Standardized [for both door and gear changes] stratified mean number per tow at age and standardized stratified mean weight (kg) per tow of Atlantic cod in NEFSC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine, 1963-1993.

Table 3. Stratified mean catch per tow in numbers and weight (kg) of Atlantic cod in State of Massachusetts inshore spring and autumn bottom trawl surveys in territorial waters adjacent to the Georges Bank area (Mass. Regions 1-3) and in the Gulf of Maine (Mass. Regions 4-5), 1978 - 1993.

Appendix 1:Table 1. Stratified mean catch per tow at age (numbers) of Atlantic cod in NEFC offshore spring and autumn bottom trawl surveys in the Gulf of Maine, 1963 - 1994. [a,b]

	Age Group											Totals						Str.Mean
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+	Wgt per tow
Spring [c]																		
1968	0.082	0.393	0.791	0.902	0.542	0.345	0.133	0.083	0.071	0.038	0.106	3.486	3.404	3.011	2.220	1.318	0.776	11.06
1969	0.000	0.000	0.023	0.197	0.564	0.517	0.406	0.164	0.092	0.057	0.065	2.085	2.085	2.085	2.062	1.865	1.301	8.15
1970	0.000	0.102	0.079	0.035	0.060	0.175	0.299	0.394	0.048	0.038	0.184	1.414	1.414	1.312	1.233	1.198	1.138	6.83
1971	0.000	0.016	0.091	0.070	0.187	0.031	0.053	0.192	0.132	0.099	0.046	0.917	0.917	0.901	0.810	0.740	0.553	4.31
1972	0.000	0.226	0.098	0.333	0.126	0.128	0.023	0.068	0.065	0.147	0.105	1.319	1.319	1.093	0.995	0.662	0.536	4.96
1973	0.000	0.022	2.724	0.581	0.397	0.224	0.125	0.061	0.143	0.161	0.392	4.830	4.830	4.808	2.084	1.503	1.106	11.60
1974	0.000	0.305	0.036	0.871	0.211	0.142	0.073	0.031	0.031	0.013	0.149	1.862	1.862	1.557	1.521	0.650	0.439	4.59
1975	0.004	0.060	0.448	0.068	0.683	0.166	0.071	0.003	0.003	0.012	0.092	1.610	1.606	1.546	1.098	1.030	0.347	3.72
1976	0.000	0.027	0.195	0.672	0.098	0.575	0.055	0.069	0.042	0.000	0.047	1.780	1.780	1.753	1.558	0.886	0.788	4.66
1977	0.000	0.016	0.191	0.334	1.278	0.070	0.507	0.004	0.065	0.000	0.024	2.489	2.489	2.473	2.282	1.948	0.670	5.27
1978	0.000	0.022	0.067	0.183	0.223	0.491	0.048	0.205	0.005	0.068	0.005	1.317	1.317	1.295	1.228	1.045	0.822	4.75
1979	0.028	0.343	1.045	0.136	0.320	0.257	0.439	0.038	0.091	0.008	0.034	2.739	2.711	2.368	1.323	1.187	0.867	5.86
1980	0.057	0.057	0.357	0.278	0.100	0.339	0.194	0.246	0.000	0.105	0.011	1.744	1.687	1.630	1.273	0.995	0.895	5.69
1981	0.000	0.823	0.537	0.800	0.987	0.266	0.233	0.089	0.126	0.086	0.000	3.947	3.947	3.124	2.587	1.787	0.800	9.94
1982	0.012	0.273	0.827	0.419	0.563	0.701	0.095	0.088	0.000	0.034	0.032	3.044	3.032	2.759	1.932	1.513	0.950	7.94
1983	0.008	0.401	0.627	0.534	0.411	0.229	0.116	0.059	0.000	0.058	0.065	2.508	2.500	2.099	1.472	0.938	0.527	6.48
1984	0.000	0.097	0.662	0.735	0.475	0.122	0.034	0.037	0.019	0.000	0.000	2.181	2.181	2.084	1.422	0.687	0.212	3.60
1985	0.000	0.028	0.238	0.622	0.665	0.677	0.095	0.114	0.052	0.000	0.026	2.517	2.517	2.489	2.251	1.629	0.964	7.65
1986	0.000	0.417	0.330	0.647	0.387	0.074	0.046	0.027	0.011	0.000	0.018	1.957	1.957	1.540	1.210	0.563	0.176	3.60
1987	0.000	0.049	0.638	0.486	0.300	0.128	0.011	0.045	0.011	0.000	0.014	1.682	1.682	1.633	0.995	0.509	0.209	3.01
1988	0.029	0.663	1.053	0.633	0.355	0.217	0.087	0.063	0.000	0.027	0.000	3.127	3.098	2.435	1.382	0.749	0.394	3.30
1989	0.000	0.029	0.822	1.000	0.800	0.114	0.097	0.000	0.000	0.000	0.000	2.862	2.862	2.833	2.011	1.011	0.211	3.78
1990	0.000	0.000	0.241	1.680	0.794	0.211	0.041	0.023	0.000	0.000	0.000	2.990	2.990	2.990	2.749	1.069	0.275	4.59
1991	0.000	0.054	0.265	0.449	1.870	0.339	0.030	0.023	0.000	0.000	0.000	3.030	3.030	2.976	2.711	2.262	0.392	4.31
1992	0.000	0.050	0.230	0.240	0.280	1.310	0.220	0.070	0.000	0.010	0.000	2.410	2.410	2.350	2.130	1.890	1.610	8.66
1993	0.000	0.200	0.500	0.800	0.330	0.090	0.480	0.060	0.020	0.000	0.023	2.503	2.503	2.303	1.803	1.003	0.673	5.87
1994	0.000	0.039	0.360	0.492	0.263	0.152	0.065	0.159	0.034	0.025	0.023	1.612	1.612	1.573	1.213	0.721	0.458	3.62

[a] Strata 26-30 and 36-40.

[b] Catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey.

[c] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these gear differences.

Appendix 1:Table 1 (Continued). [a,b]

Year	Age Group 0	1	2	3	4	5	6	7	8	9	10+	Totals 0+	1+	2+	3+	4+	5+	Str.Mean Wgt per tow
Autumn																		
1963	0.032	0.416	0.865	0.803	0.544	0.371	0.344	0.192	0.117	0.061	0.048	3.793	3.761	3.345	2.480	1.677	1.133	11.08
1964	0.000	0.059	0.078	0.302	0.549	0.547	0.502	0.239	0.152	0.073	0.065	2.566	2.566	2.507	2.429	2.127	1.578	14.07
1965	0.001	0.545	0.564	0.528	0.481	0.318	0.240	0.109	0.051	0.028	0.016	2.881	2.880	2.335	1.771	1.243	0.762	7.41
1966	0.109	0.131	0.410	0.447	0.460	0.358	0.283	0.123	0.050	0.031	0.023	2.425	2.316	2.185	1.775	1.328	0.868	7.97
1967	0.008	0.083	0.138	0.368	0.430	0.246	0.172	0.104	0.045	0.026	0.022	1.642	1.634	1.551	1.413	1.045	0.615	5.70
1968	0.008	0.023	0.115	0.461	0.805	0.624	0.402	0.167	0.100	0.046	0.061	2.812	2.804	2.781	2.666	2.205	1.400	12.00
1969	0.010	0.038	0.079	0.227	0.404	0.354	0.299	0.141	0.093	0.083	0.040	1.768	1.758	1.720	1.641	1.414	1.010	9.49
1970	0.476	0.603	0.170	0.353	0.211	0.313	0.271	0.506	0.084	0.060	0.094	3.141	2.665	2.062	1.892	1.539	1.328	10.14
1971	0.863	0.114	0.153	0.135	0.383	0.295	0.278	0.163	0.204	0.128	0.082	2.798	1.935	1.821	1.668	1.533	1.150	10.20
1972	0.020	3.576	0.780	0.978	0.150	0.060	0.110	0.025	0.102	0.155	0.010	5.966	5.946	2.370	1.590	0.612	0.462	8.00
1973	0.408	0.210	1.393	0.089	0.325	0.136	0.050	0.018	0.033	0.108	0.087	2.857	2.449	2.239	0.846	0.757	0.432	5.39
1974	0.181	0.720	0.121	1.118	0.187	0.230	0.050	0.008	0.008	0.027	0.127	2.777	2.596	1.876	1.755	0.637	0.450	5.54
1975	0.030	0.094	1.966	0.086	1.510	0.163	0.070	0.011	0.002	0.002	0.008	3.942	3.912	3.818	1.852	1.766	0.256	5.32
1976	0.000	0.156	0.134	0.405	0.064	0.492	0.037	0.061	0.000	0.010	0.020	1.379	1.379	1.223	1.089	0.684	0.620	4.16
1977	0.000	0.018	0.291	0.446	0.937	0.123	0.481	0.031	0.079	0.018	0.078	2.502	2.502	2.484	2.193	1.747	0.810	9.42
1978	0.202	1.111	0.301	0.907	0.532	1.160	0.091	0.264	0.007	0.049	0.041	4.665	4.463	3.352	3.051	2.144	1.612	11.88
1979	0.003	0.236	0.381	0.104	0.536	0.251	0.501	0.033	0.138	0.000	0.053	2.236	2.233	1.997	1.616	1.512	0.976	10.83
1980	0.022	1.026	2.111	1.423	0.403	0.188	0.272	0.168	0.024	0.015	0.058	5.710	5.688	4.662	2.551	1.128	0.725	13.09
1981	0.008	0.397	0.245	0.352	0.304	0.057	0.076	0.024	0.069	0.000	0.018	1.550	1.542	1.145	0.900	0.548	0.244	4.97
1982	0.000	0.449	2.014	1.585	0.748	0.159	0.000	0.025	0.000	0.000	0.000	4.980	4.980	4.531	2.517	0.932	0.184	9.92
1983	0.029	1.064	0.626	0.546	0.089	0.169	0.126	0.000	0.000	0.000	0.058	2.707	2.678	1.614	0.988	0.442	0.353	5.44
1984	0.028	0.246	0.270	0.362	0.256	0.141	0.131	0.057	0.000	0.020	0.042	1.553	1.525	1.279	1.009	0.647	0.391	5.44
1985	0.266	0.378	0.910	0.763	0.209	0.218	0.074	0.000	0.034	0.021	0.049	2.922	2.656	2.278	1.368	0.605	0.396	8.49
1986	0.000	0.301	0.490	0.654	0.333	0.086	0.042	0.000	0.000	0.024	0.021	1.951	1.951	1.650	1.160	0.506	0.173	5.10
1987	0.138	0.599	1.324	0.600	0.257	0.061	0.000	0.000	0.000	0.000	0.000	2.979	2.841	2.242	0.918	0.318	0.061	3.41
1988	0.000	1.951	2.245	0.960	0.528	0.110	0.076	0.033	0.000	0.000	0.000	5.903	5.903	3.952	1.707	0.747	0.219	6.61
1989	0.000	0.526	3.026	1.717	0.372	0.220	0.018	0.000	0.000	0.011	0.000	5.890	5.890	5.364	2.338	0.621	0.249	6.84
1990	0.008	0.037	0.464	2.080	0.788	0.352	0.036	0.013	0.000	0.000	0.000	3.778	3.770	3.733	3.269	1.189	0.401	7.33
1991	0.010	0.180	0.180	0.280	0.800	0.100	0.000	0.030	0.000	0.000	0.000	1.580	1.570	1.390	1.210	0.930	0.130	4.15
1992	0.060	0.290	0.450	0.140	0.040	0.330	0.110	0.000	0.010	0.000	0.000	1.430	1.370	1.080	0.630	0.490	0.450	2.45
1993	0.050	0.250	0.720	0.460	0.040	0.000	0.040	0.000	0.000	0.000	0.000	1.560	1.510	1.260	0.540	0.080	0.040	1.50

[a] Strata 26-30 and 36-40.

[b] Catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey.

Appendix 1:Table 2. Standardized [for both door and gear changes] stratified mean number per tow at age and standardized stratified mean weight (kg) per tow of Atlantic cod in NEFSC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine, 1963-1994. [a,b]

	Age Group											Totals						Standardized
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+	Mean Wt (kg)/Tow
Spring [c,d,e]																		
1968	0.128	0.613	1.234	1.407	0.846	0.538	0.207	0.129	0.111	0.059	0.165	5.438	5.310	4.697	3.463	2.056	1.211	17.92
1969	0.000	0.000	0.036	0.307	0.880	0.807	0.633	0.256	0.144	0.089	0.101	3.253	3.253	3.253	3.217	2.909	2.030	13.20
1970	0.000	0.159	0.123	0.055	0.094	0.273	0.466	0.615	0.075	0.059	0.287	2.206	2.206	2.047	1.923	1.869	1.775	11.06
1971	0.000	0.025	0.142	0.109	0.292	0.048	0.083	0.300	0.206	0.154	0.072	1.431	1.431	1.406	1.264	1.154	0.863	6.98
1972	0.000	0.353	0.153	0.519	0.197	0.200	0.036	0.106	0.101	0.229	0.164	2.058	2.058	1.705	1.552	1.033	0.836	8.04
1973	0.000	0.034	4.249	0.906	0.619	0.349	0.195	0.095	0.223	0.251	0.612	7.535	7.535	7.500	3.251	2.345	1.725	18.79
1974	0.000	0.476	0.056	1.359	0.329	0.222	0.114	0.048	0.048	0.020	0.232	2.905	2.905	2.429	2.373	1.014	0.685	7.44
1975	0.006	0.094	0.699	0.106	1.065	0.259	0.111	0.005	0.005	0.019	0.144	2.512	2.505	2.412	1.713	1.607	0.541	6.03
1976	0.000	0.042	0.304	1.048	0.153	0.897	0.086	0.108	0.066	0.000	0.073	2.777	2.777	2.735	2.430	1.382	1.229	7.55
1977	0.000	0.025	0.298	0.521	1.994	0.109	0.791	0.006	0.101	0.000	0.037	3.883	3.883	3.858	3.560	3.039	1.045	8.54
1978	0.000	0.034	0.105	0.285	0.348	0.766	0.075	0.320	0.008	0.106	0.008	2.055	2.055	2.020	1.916	1.630	1.282	7.70
1979	0.044	0.535	1.630	0.212	0.499	0.401	0.685	0.059	0.142	0.012	0.053	4.273	4.229	3.694	2.064	1.852	1.353	9.49
1980	0.070	0.070	0.440	0.343	0.123	0.418	0.239	0.303	0.000	0.129	0.014	2.149	2.079	2.009	1.569	1.226	1.103	6.18
1981	0.000	1.014	0.662	0.986	1.216	0.328	0.287	0.110	0.155	0.106	0.000	4.864	4.864	3.850	3.188	2.202	0.986	10.79
1982	0.015	0.336	1.019	0.516	0.694	0.864	0.117	0.108	0.000	0.042	0.039	3.751	3.737	3.400	2.381	1.865	1.171	8.62
1983	0.012	0.626	0.978	0.833	0.641	0.357	0.181	0.092	0.000	0.090	0.101	3.912	3.900	3.274	2.296	1.463	0.822	10.50
1984	0.000	0.151	1.033	1.147	0.741	0.190	0.053	0.058	0.030	0.000	0.000	3.402	3.402	3.251	2.218	1.072	0.331	5.83
1985	0.000	0.028	0.238	0.622	0.665	0.677	0.095	0.114	0.052	0.000	0.026	2.517	2.517	2.489	2.251	1.629	0.964	7.65
1986	0.000	0.417	0.330	0.647	0.387	0.074	0.046	0.027	0.011	0.000	0.018	1.957	1.957	1.540	1.210	0.563	0.176	3.60
1987	0.000	0.049	0.638	0.486	0.300	0.128	0.011	0.045	0.011	0.000	0.014	1.682	1.682	1.633	0.995	0.509	0.209	3.01
1988	0.029	0.663	1.053	0.633	0.355	0.217	0.087	0.063	0.000	0.027	0.000	3.127	3.098	2.435	1.382	0.749	0.394	3.30
1989	0.000	0.023	0.649	0.790	0.632	0.090	0.077	0.000	0.000	0.000	0.000	2.261	2.261	2.238	1.589	0.799	0.167	2.53
1990	0.000	0.000	0.190	1.327	0.627	0.167	0.032	0.018	0.000	0.000	0.000	2.362	2.362	2.362	2.172	0.845	0.217	3.08
1991	0.000	0.043	0.209	0.355	1.477	0.268	0.024	0.018	0.000	0.000	0.000	2.394	2.394	2.351	2.142	1.787	0.310	2.89
1992	0.000	0.050	0.230	0.240	0.280	1.310	0.220	0.070	0.000	0.010	0.000	2.410	2.410	2.360	2.130	1.890	1.610	8.66
1993	0.000	0.200	0.500	0.800	0.330	0.090	0.480	0.060	0.020	0.000	0.023	2.503	2.503	2.303	1.803	1.003	0.673	5.87
1994	0.000	0.031	0.284	0.389	0.208	0.120	0.051	0.126	0.027	0.020	0.018	1.273	1.273	1.243	0.958	0.570	0.362	2.43

[a] Strata 26-30 and 36-40.

[b] Catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey.

[c] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these differences.

[d] During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portugeuse polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFC 1991).

[e] In the Gulf of Maine, spring surveys during 1980-1982, 1989-1991 amd 1994, and autumn surveys during 1977-1978, 1980, 1989-1991 and 1993 were accomplished with the R/V DELAWARE II; in all other years, the surveys were accomplished using the R/V ALBATROSS IV. Adjustments have been made to the R/V DELAWARE II catch per tow data to standardize these to R/V ALBTATROSS IV equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFC 1991).

Appendix 1:Table 2 (Continued). [a,b]

Year	Age Group 0	1	2	3	4	5	6	7	8	9	10+	Totals 0+	1+	2+	3+	4+	5+	Standardized Mean Wt (kg)/Tow
Autumn [d,e]																		
1963	0.050	0.649	1.349	1.253	0.849	0.579	0.537	0.300	0.183	0.095	0.075	5.917	5.867	5.218	3.869	2.616	1.767	17.95
1964	0.000	0.092	0.122	0.471	0.856	0.853	0.783	0.373	0.237	0.114	0.101	4.003	4.003	3.911	3.789	3.318	2.462	22.79
1965	0.002	0.850	0.880	0.824	0.750	0.496	0.374	0.170	0.080	0.044	0.025	4.494	4.493	3.643	2.763	1.939	1.189	12.00
1966	0.170	0.204	0.640	0.697	0.718	0.558	0.441	0.192	0.078	0.048	0.036	3.783	3.613	3.409	2.769	2.072	1.354	12.91
1967	0.012	0.129	0.215	0.574	0.671	0.384	0.268	0.162	0.070	0.041	0.034	2.562	2.549	2.420	2.204	1.630	0.959	9.23
1968	0.012	0.036	0.179	0.719	1.256	0.973	0.627	0.261	0.156	0.072	0.095	4.387	4.374	4.338	4.159	3.440	2.184	19.44
1969	0.016	0.059	0.123	0.354	0.630	0.552	0.466	0.220	0.145	0.129	0.062	2.758	2.742	2.683	2.560	2.206	1.576	15.37
1970	0.743	0.941	0.265	0.551	0.329	0.488	0.423	0.789	0.131	0.094	0.147	4.900	4.157	3.217	2.952	2.401	2.072	16.43
1971	1.346	0.178	0.239	0.211	0.597	0.460	0.434	0.254	0.318	0.200	0.128	4.365	3.019	2.841	2.602	2.391	1.794	16.52
1972	0.031	5.579	1.217	1.526	0.234	0.094	0.172	0.039	0.159	0.242	0.016	9.307	9.276	3.697	2.480	0.955	0.721	12.96
1973	0.636	0.328	2.173	0.139	0.507	0.212	0.078	0.028	0.051	0.168	0.136	4.457	3.820	3.493	1.320	1.181	0.674	8.73
1974	0.282	1.123	0.189	1.744	0.292	0.359	0.078	0.012	0.012	0.042	0.198	4.332	4.050	2.927	2.738	0.994	0.702	8.97
1975	0.047	0.147	3.067	0.134	2.356	0.254	0.109	0.017	0.003	0.003	0.012	6.150	6.103	5.956	2.889	2.755	0.399	8.62
1976	0.000	0.243	0.209	0.632	0.100	0.768	0.058	0.095	0.000	0.016	0.031	2.151	2.151	1.908	1.699	1.067	0.967	6.74
1977	0.000	0.022	0.359	0.550	1.155	0.152	0.593	0.038	0.097	0.022	0.096	3.083	3.083	3.061	2.703	2.153	0.998	10.22
1978	0.249	1.369	0.371	1.118	0.656	1.430	0.112	0.325	0.009	0.060	0.051	5.749	5.500	4.131	3.760	2.642	1.987	12.89
1979	0.005	0.368	0.594	0.162	0.836	0.392	0.782	0.051	0.215	0.000	0.083	3.488	3.483	3.115	2.521	2.359	1.523	17.54
1980	0.027	1.264	2.602	1.754	0.497	0.232	0.335	0.207	0.030	0.018	0.071	7.037	7.010	5.745	3.144	1.390	0.893	14.21
1981	0.012	0.619	0.382	0.549	0.474	0.089	0.119	0.037	0.108	0.000	0.028	2.418	2.406	1.786	1.404	0.855	0.381	8.05
1982	0.000	0.700	3.142	2.473	1.167	0.248	0.000	0.039	0.000	0.000	0.000	7.769	7.769	7.068	3.927	1.454	0.287	16.07
1983	0.045	1.660	0.977	0.852	0.139	0.264	0.197	0.000	0.000	0.000	0.090	4.223	4.178	2.518	1.541	0.690	0.551	8.81
1984	0.044	0.384	0.421	0.565	0.399	0.220	0.204	0.089	0.000	0.031	0.066	2.423	2.379	1.995	1.574	1.009	0.610	8.81
1985	0.266	0.378	0.910	0.763	0.209	0.218	0.074	0.000	0.034	0.021	0.049	2.922	2.656	2.278	1.368	0.605	0.396	8.49
1986	0.000	0.301	0.490	0.654	0.333	0.086	0.042	0.000	0.000	0.024	0.021	1.951	1.951	1.650	1.160	0.506	0.173	5.10
1987	0.138	0.599	1.324	0.600	0.257	0.061	0.000	0.000	0.000	0.000	0.000	2.979	2.841	2.242	0.918	0.318	0.061	3.41
1988	0.000	1.951	2.245	0.960	0.528	0.110	0.076	0.033	0.000	0.000	0.000	5.903	5.903	3.952	1.707	0.747	0.219	6.61
1989	0.000	0.416	2.391	1.356	0.294	0.174	0.014	0.000	0.000	0.009	0.000	4.653	4.653	4.238	1.847	0.491	0.197	4.58
1990	0.006	0.029	0.367	1.643	0.623	0.278	0.028	0.010	0.000	0.000	0.000	2.985	2.978	2.949	2.583	0.939	0.317	4.91
1991	0.008	0.142	0.142	0.221	0.632	0.079	0.000	0.024	0.000	0.000	0.000	1.248	1.240	1.098	0.956	0.735	0.103	2.78
1992	0.060	0.290	0.450	0.140	0.040	0.330	0.110	0.000	0.010	0.000	0.000	1.430	1.370	1.080	0.630	0.490	0.450	2.45
1993	0.040	0.198	0.569	0.363	0.032	0.000	0.032	0.000	0.000	0.000	0.000	1.232	1.193	0.995	0.427	0.063	0.032	1.00

[a] Strata 26-30 and 36-40.

[b] Catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey.

[d] During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portugeuse polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFC 1991).

[e] In the Gulf of Maine, spring surveys during 1980-1982, 1989-1991 and 1994, and autumn surveys during 1977-1978, 1980, 1989-1991 and 1993 were accomplished with the R/V DELAWARE II; in all other years, the surveys were accomplished using the R/V ALBATROSS IV. Adjustments have been made to the R/V DELAWARE II catch per tow data to standardize these to R/V ALBTATROSS IV equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFC 1991).

Appendix 1:Table 3. Stratified mean catch per tow in numbers and weight (kg) of Atlantic cod in State of Massachusetts inshore spring and autumn bottom trawl surveys in territorial waters adjacent to the Gulf of Maine (Mass. Regions 4-5), 1978 - 1994. [a]

	Age Group											Totals				Stratified Mean Weight
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	(kg)
Gulf of Maine Area (Mass. Regions 4-5)																
Spring																
1978	21.965	12.784	4.162	4.572	0.872	1.028	0.000	0.000	0.023	0.000	0.000	45.406	23.441	10.657	6.495	12.16
1979	56.393	36.630	2.581	1.533	4.659	1.995	0.183	0.000	0.000	0.000	0.069	104.043	47.650	11.020	8.439	20.53
1980	8.156	50.311	12.679	0.971	0.745	0.737	0.080	0.214	0.000	0.025	0.000	73.918	65.762	15.451	2.772	17.71
1981	19.753	24.794	23.884	3.122	1.279	0.041	0.146	0.022	0.022	0.000	0.000	73.063	53.310	28.516	4.632	21.79
1982	1.489	16.235	7.060	3.418	1.147	0.232	0.011	0.057	0.045	0.000	0.000	29.694	28.205	11.970	4.910	13.42
1983	0.453	27.703	18.572	5.331	0.501	1.221	0.142	0.022	0.000	0.000	0.000	53.945	53.492	25.789	7.217	19.77
1984	0.206	2.896	5.408	2.271	0.865	0.138	0.162	0.000	0.000	0.000	0.000	11.946	11.740	8.844	3.436	8.63
1985	0.793	2.711	3.822	2.794	0.692	0.000	0.000	0.000	0.000	0.000	0.000	10.812	10.019	7.308	3.486	6.42
1986	0.957	19.960	3.222	0.887	0.426	0.090	0.019	0.000	0.000	0.000	0.000	25.561	24.604	4.644	1.422	7.77
1987	0.659	8.590	6.997	2.268	0.257	0.147	0.048	0.000	0.000	0.087	0.000	19.053	18.394	9.804	2.807	9.59
1988	1.595	11.841	11.356	2.511	1.370	0.000	0.039	0.000	0.000	0.000	0.000	28.712	27.117	15.276	3.920	9.66
1989	0.157	20.679	25.260	6.580	0.458	0.106	0.124	0.000	0.000	0.000	0.000	53.364	53.207	32.528	7.268	18.26
1990	4.10	6.33	6.89	17.77	2.64	0.18	0.05	0.02	0.000	0.000	0.000	37.980	33.88	27.55	20.66	19.51
1991	0.32	5.88	3.56	2.54	5.03	0.36	0.000	0.000	0.000	0.000	0.000	17.69	17.37	11.49	7.93	11.37
1992	1.36	6.42	6.35	3.58	0.65	1.37	0.12	0.04	0.00	0.00	0.00	19.88	18.53	12.11	5.76	10.10
1993	69.03	3.40	7.76	3.60	1.45	0.05	0.30	0.00	0.00	0.00	0.00	85.59	16.56	13.16	5.40	7.63
1994	3.90	4.07	6.15	2.45	0.53	0.16	0.03	0.04	0.00	0.02	0.00	17.35	13.45	9.38	3.23	4.83
Autumn																
1978	151.533	2.082	0.000	0.120	0.140	0.318	0.000	0.080	0.000	0.000	0.000	154.273	2.740	0.658	0.658	3.02
1979	4.933	3.430	0.042	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.000	8.431	3.498	0.068	0.026	0.99
1980	5.680	8.834	0.052	0.000	0.000	0.050	0.000	0.000	0.000	0.000	0.000	14.616	8.936	0.102	0.050	1.57
1981	2.018	5.652	7.290	0.729	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.689	13.671	8.019	0.729	6.65
1982	4.667	2.346	1.005	0.060	0.050	0.000	0.000	0.000	0.000	0.000	0.000	8.128	3.461	1.115	0.110	1.35
1983	1.308	0.651	0.100	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.072	0.764	0.113	0.013	0.18
1984	12.296	0.344	0.022	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	12.675	0.379	0.035	0.013	0.18
1985	2.832	0.419	0.018	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.279	0.447	0.028	0.010	0.09
1986	2.478	1.150	0.833	0.000	0.067	0.000	0.000	0.000	0.000	0.000	0.000	4.528	2.050	0.900	0.067	0.55
1987	389.584	2.386	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	391.990	2.406	0.020	0.000	0.45
1988	4.571	20.490	0.679	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	25.740	21.169	0.679	0.000	1.57
1989	2.971	2.700	0.350	0.210	0.185	0.000	0.000	0.000	0.000	0.000	0.000	6.416	3.445	0.745	0.395	1.27
1990	9.37	9.13	1.74	0.31	0.06	0.03	0.000	0.000	0.000	0.000	0.000	20.638	11.27	2.14	0.40	1.56
1991	4.65	4.20	0.81	0.03	0.05	0.01	0.00	0.00	0.00	0.00	0.00	9.74	5.09	0.89	0.08	0.80
1992	24.30	2.01	0.11	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	26.48	2.18	0.17	0.06	0.42
1993	49.92	3.32	0.61	0.33	0.00	0.00	0.01	0.00	0.00	0.00	0.00	54.21	4.29	0.97	0.36	1.97

[a] Massachusetts sampling strata 25-36.

Appendix 2. Full listing of final ADAPT VPA calibration for Gulf of Maine cod including:

Estimates of 1994 N for ages 2-6 using:
NEFSC spring and autumn surveys for ages 2-6,
Massachusetts DMF spring surveys for age 2-4 and autumn surveys for age 2, and
USA commercial LPUE indices for ages 3-6.

ADAPT Run Number 332 1994 11 8 9 57 57
COD: **GULF OF MAINE STOCK - GMCOD94: Final Subcommittee Run**

Output option selected for input parameters: full
Output option selected for results: full

INPUT PARAMETERS AND OPTIONS SELECTED

Natural mortality is 0.2

Oldest age (not in the plus group) is 6

For all yrs prior to the terminal year (1993), backcalculated
stock sizes for the following ages used to estimate
total mortality (Z) for age 6: 4 5 6
This method for estimating F on the oldest age is generally used
when a flat-topped partial recruitment curve is thought to be
characteristic of the stock.

F for age 7+ is then calculated from the following
ratios of F[age 7+] to F[age 6]

1982	1.0000
1983	1.0000
1984	1.0000
1985	1.0000
1986	1.0000
1987	1.0000
1988	1.0000
1989	1.0000
1990	1.0000
1991	1.0000
1992	1.0000
1993	1.0000

Stock size of the 7+ group is then calculated
using the following method: CATCHEQ

Partial recruitment estimate for 1993

1	0.0001
2	0.0540
3	0.4020
4	1.0000
5	1.0000
6	1.0000

Objective function is SUM W*(LOG(OBS) - LOG(PRED))**2

Indices normalized (by dividing by mean observed value)
before tuning to VPA stocksizes

The residuals for years prior to the terminal year are downweighted
using the following algorithm: NONE

Biomass estimates (other than SSB) reflect mean stock sizes.
SSB calculated as in the NEFSC projection program
(see note below SSB table for description of the algorithm).

Initial estimates of parameters for the Marquardt algorithm
and lower and upper bounds on the parameter estimates:

Par.	Initial Est	Lower Bnd	Upper Bnd
N 2	3.0000000E3	1.0000000E0	1.0000000E6
N 3	3.0000000E3	1.0000000E0	1.0000000E6
N 4	5.0000000E2	1.0000000E0	1.0000000E6
N 5	5.0000000E2	1.0000000E0	1.0000000E6
N 6	5.0000000E2	1.0000000E0	1.0000000E6
qRV SPR 2	1.0000000E-2	0.0000000E0	1.0000000E0
qRV SPR 3	1.0000000E-2	0.0000000E0	1.0000000E0
qRV SPR 4	1.0000000E-2	0.0000000E0	1.0000000E0
qRV SPR 5	1.0000000E-2	0.0000000E0	1.0000000E0
qRV SPR 6	1.0000000E-2	0.0000000E0	1.0000000E0
qRV FAL 2	1.0000000E-2	0.0000000E0	1.0000000E0
qRV FAL 3	1.0000000E-2	0.0000000E0	1.0000000E0
qRV FAL 4	1.0000000E-2	0.0000000E0	1.0000000E0
qRV FAL 5	1.0000000E-2	0.0000000E0	1.0000000E0
qRV FAL 6	1.0000000E-2	0.0000000E0	1.0000000E0
qCM CPE 3	1.0000000E-2	0.0000000E0	1.0000000E0
qCM CPE 4	1.0000000E-2	0.0000000E0	1.0000000E0
qCM CPE 5	1.0000000E-2	0.0000000E0	1.0000000E0
qCM CPE 6	1.0000000E-2	0.0000000E0	1.0000000E0
qMA SPR 2	1.0000000E-2	0.0000000E0	1.0000000E0
qMA SPR 3	1.0000000E-2	0.0000000E0	1.0000000E0
qMA SPR 4	1.0000000E-2	0.0000000E0	1.0000000E0
qMA FAL 2	1.0000000E-2	0.0000000E0	1.0000000E0

The following indices of abundance are available:

1	RV SPR 2
2	RV SPR 3
3	RV SPR 4
4	RV SPR 5
5	RV SPR 6
6	RV FAL 2
7	RV FAL 3
8	RV FAL 4
9	RV FAL 5
10	RV FAL 6
11	CM CPE 2
12	CM CPE 3
13	CM CPE 4
14	CM CPE 5
15	CM CPE 6
16	MA SPR 2
17	MA SPR 3
18	MA SPR 4
19	MA FAL 2
20	MA FAL 3
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	

Indices that will be used in this run are: 1 2 3 4 5 6 7 8 9 10 12 13 14 15 16 17 18 19

Obs Indices (before transformation) by index & yr; with index means

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994*******	
1	1.019	0.978	1.033	0.238	0.330	0.638	1.053	0.649	0.190	0.209	0.230	0.500	0.284	0.566
2	0.516	0.833	1.147	0.622	0.647	0.486	0.633	0.790	1.327	0.355	0.240	0.800	0.389	0.676
3	0.694	0.641	0.741	0.665	0.387	0.300	0.355	0.632	0.627	1.477	0.280	0.330	0.208	0.564
4	0.864	0.357	0.190	0.677	0.074	0.128	0.217	0.090	0.167	0.268	1.310	0.090	0.120	0.350
5	0.117	0.181	0.053	0.095	0.046	0.011	0.087	0.077	0.032	0.024	0.220	0.480	0.051	0.113
6	0.619	0.700	1.660	0.384	0.378	0.301	0.599	1.951	0.416	0.029	0.142	0.290	0.198	0.590
7	0.382	3.142	0.977	0.421	0.910	0.490	1.324	2.245	2.391	0.367	0.142	0.450	0.569	1.062
8	0.549	2.473	0.852	0.565	0.763	0.654	0.600	0.960	1.356	1.643	0.221	0.140	0.363	0.857
9	0.474	1.167	0.139	0.399	0.209	0.333	0.257	0.528	0.294	0.623	0.632	0.040	0.032	0.394
10	0.089	0.248	0.264	0.220	0.218	0.086	0.061	0.110	0.174	0.278	0.079	0.330	0.000	0.180
12	0.090	0.134	0.055	0.050	0.081	0.023	0.059	0.077	0.188	0.046	0.021	0.063	-999.000	0.074
13	0.055	0.052	0.054	0.034	0.027	0.032	0.029	0.048	0.092	0.156	0.017	0.029	-999.000	0.052
14	0.026	0.026	0.014	0.021	0.008	0.007	0.011	0.013	0.014	0.025	0.062	0.005	-999.000	0.019
15	0.003	0.015	0.007	0.004	0.005	0.002	0.002	0.003	0.006	0.005	0.006	0.017	-999.000	0.006
16	7.060	18.572	5.408	3.822	3.222	6.997	11.356	25.260	6.890	3.560	6.350	7.760	6.150	8.647
17	3.418	5.331	2.271	2.794	0.887	2.268	2.511	6.580	17.770	2.540	3.580	3.600	2.450	4.308
18	1.147	0.501	0.865	0.692	0.426	0.257	1.370	0.458	2.640	5.030	0.650	1.450	0.530	1.232
19	5.652	2.346	0.651	0.344	0.419	1.150	2.386	20.490	2.700	9.130	4.200	2.010	3.320	4.215

SUMMARY OF WEIGHTING USED IN THE OBJECTIVE FUNCTION

EXOGENOUS WEIGHTS BY INDEX AND YR (omega)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-99.00
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-99.00
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-99.00
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-99.00
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-99.00
16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Negative weights in the above table indicate missing values

DOWNWEIGHTS BY YEAR (delta)

1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

ITERATIVE RE-WEIGHTS BY INDEX (chi)

1	2	3	4	5	6	7	8	9	10	12	13	14	15	16
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

17	18	19
1.0000	1.0000	1.0000

FINAL SS WEIGHTS BY INDEX NUMBER AND YR - GMCOD94

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-99.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-99.0000
13	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-99.0000
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-99.0000
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-99.0000
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
17	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
18	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
19	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Negative weights in the above table indicate missing values

CATCH AT AGE (thousands) - GMCOD94

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0	0	0	0	0	0	0	0	0	0	0	0
2	1380	866	446	407	84	216	160	337	205	344	313	76
3	1633	2357	1240	1445	2164	595	1443	1583	3425	934	530	1487
4	1143	1058	1500	991	813	1109	953	1454	2064	4161	484	641
5	633	638	437	630	250	277	406	449	430	851	2018	129
6	69	422	194	128	177	66	43	81	157	143	202	457
7	230	155	136	136	95	79	30	56	99	79	84	36
1+	5088	5496	3953	3737	3583	2342	3035	3960	6380	6512	3631	2826

CAA summary for ages 2 5 3 5 4 5 5 5

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
2	4789	4919	3623	3473	3311	2197	2962	3823	6124	6290	3345	2333
3	3409	4053	3177	3066	3227	1981	2802	3486	5919	5946	3032	2257
4	1776	1696	1937	1621	1063	1386	1359	1903	2494	5012	2502	770
5	633	638	437	630	250	277	406	449	430	851	2018	129

WT AT AGE (MID-YR) in kg. - GMCOD94

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900
2	1.156	1.164	1.159	1.260	1.304	1.313	1.268	1.247	1.071	1.130	1.533	1.293
3	1.664	1.660	1.670	1.746	1.837	1.684	1.881	1.776	1.692	1.568	1.922	1.889
4	2.764	2.475	2.721	2.840	2.923	3.283	2.426	2.993	2.271	2.512	2.714	2.513
5	4.770	3.778	3.677	4.466	4.619	4.831	5.166	3.864	4.265	4.136	3.061	4.356
6	6.739	5.962	5.898	5.525	6.067	6.824	6.767	4.872	7.645	7.309	5.000	6.174
7	11.313	9.747	10.186	9.764	10.238	10.312	11.512	12.179	13.732	11.449	10.614	11.063

WT AT AGE (JAN 1) in kg. - GMCOD94

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.791	0.793	0.761	0.748	0.745	0.758	0.765	0.825	0.803	0.690	0.751	0.751	0.764
2	0.965	1.024	1.021	1.065	1.083	1.087	1.068	1.059	0.982	1.008	1.175	1.079	1.079
3	1.364	1.385	1.394	1.423	1.521	1.482	1.572	1.501	1.453	1.296	1.474	1.702	1.550
4	2.364	2.029	2.125	2.178	2.259	2.456	2.021	2.373	2.008	2.062	2.063	2.198	2.097
5	4.267	3.231	3.017	3.486	3.622	3.758	4.118	3.062	3.573	3.065	2.773	3.438	2.874
6	5.670	5.333	4.720	4.507	5.205	5.614	5.718	5.017	5.435	5.583	4.548	4.347	5.519
7	11.313	9.747	10.186	9.764	10.238	10.312	11.512	12.179	13.732	11.449	10.614	11.063	11.063

Weights at age at the start of the spawning season are assumed
to be the same as the Jan1 weight at age estimates.

PERCENT MATURE (females) - GMCOD94

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	7	7	7	4	4	4	4	4	9	9	9	9
2	26	26	26	48	48	48	48	48	24	24	24	24
3	61	61	61	95	95	95	95	95	54	54	54	54
4	88	88	88	100	100	100	100	100	81	81	81	81
5	97	97	97	100	100	100	100	100	94	94	94	94
6	100	100	100	100	100	100	100	100	98	98	98	98
7	100	100	100	100	100	100	100	100	100	100	100	100

SEX RATIO (Percent Female) - GMCOD94

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	50	50	50	50	50	50	50	50	50	50	50	50
2	50	50	50	50	50	50	50	50	50	50	50	50
3	50	50	50	50	50	50	50	50	50	50	50	50
4	50	50	50	50	50	50	50	50	50	50	50	50
5	50	50	50	50	50	50	50	50	50	50	50	50
6	50	50	50	50	50	50	50	50	50	50	50	50
7	50	50	50	50	50	50	50	50	50	50	50	50

BEGIN MARQUARDT ALGORITHM

LAMBDA 1.00000E-2
RSS 2.60916E3
NPHI 2.60916E3

par

3.00000E3	3.00000E3	5.00000E2	5.00000E2	5.00000E2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2
1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2
1.00000E-2	1.00000E-2	1.00000E-2							

LAMBDA 1.00000E-1
RSS 2.01051E3
NPHI 2.01051E3

par

3.09475E3	3.03814E3	5.46129E2	4.66918E2	4.48269E2	5.83262E-3	6.19462E-3	6.81810E-3	7.51186E-3	8.62812E-3
5.59460E-3	5.93444E-3	6.69519E-3	7.56316E-3	8.90642E-3	6.43032E-3	7.22357E-3	8.15500E-3	9.32579E-3	5.84251E-3
6.02592E-3	6.60135E-3	5.42030E-3							

LAMBDA 1.00000E0
RSS 1.57273E3
NPHI 1.57273E3

par

3.16968E3	3.06105E3	5.88395E2	4.36023E2	4.02888E2	3.74082E-3	4.15635E-3	4.93301E-3	5.88088E-3	7.59035E-3
3.47939E-3	3.85409E-3	4.77465E-3	5.95437E-3	8.04702E-3	4.44049E-3	5.47427E-3	6.83552E-3	8.77334E-3	3.75191E-3
3.95897E-3	4.65560E-3	3.29442E-3							

LAMBDA 1.00000E1
RSS 1.27267E3
NPHI 1.27267E3

par

3.13957E3	2.99344E3	6.05006E2	3.92884E2	3.52747E2	2.68451E-3	3.07060E-3	3.85294E-3	4.87160E-3	6.87719E-3
2.44456E-3	2.78264E-3	3.69009E-3	4.95352E-3	7.42959E-3	3.34630E-3	4.41745E-3	5.95623E-3	8.37831E-3	2.69483E-3
2.88161E-3	3.56907E-3	2.27879E-3							

LAMBDA 1.00000E2
RSS 1.13955E3
NPHI 1.13955E3

par

2.93651E3	2.78550E3	5.69376E2	3.38327E2	3.02663E2	2.32750E-3	2.68758E-3	3.45413E-3	4.47329E-3	6.57301E-3
2.10185E-3	2.41307E-3	3.29344E-3	4.55708E-3	7.15633E-3	2.95080E-3	4.00577E-3	5.58735E-3	8.20817E-3	2.33726E-3
2.50703E-3	3.17465E-3	1.94748E-3							

LAMBDA 1.00000E1
RSS 8.95112E2
NPHI 8.95112E2

par
2.34697E3 2.20619E3 4.49986E2 2.09230E2 1.88818E2 1.77174E-3 2.08959E-3 2.80889E-3 3.78487E-3 5.99125E-3
1.57402E-3 1.84278E-3 2.65571E-3 3.86931E-3 6.65574E-3 2.32979E-3 3.32298E-3 4.93505E-3 7.84440E-3 1.78038E-3
1.92666E-3 2.54347E-3 1.44110E-3

LAMBDA 1.00000E2
RSS 8.07820E2
NPHI 8.07820E2

par
2.25567E3 2.11045E3 4.37474E2 1.90638E2 1.68871E2 1.57206E-3 1.86776E-3 2.55981E-3 3.52387E-3 5.76889E-3
1.38724E-3 1.63479E-3 2.41136E-3 3.60813E-3 6.44172E-3 2.09425E-3 3.05842E-3 4.67519E-3 7.70615E-3 1.58017E-3
1.71371E-3 2.30302E-3 1.26391E-3

LAMBDA 1.00000E1
RSS 6.53130E2
NPHI 6.53130E2

par
1.93275E3 1.79302E3 3.76686E2 1.40571E2 1.19951E2 1.25957E-3 1.51969E-3 2.15970E-3 3.07859E-3 5.35756E-3
1.09729E-3 1.31133E-3 2.02065E-3 3.16126E-3 6.06552E-3 1.72377E-3 2.62343E-3 4.22415E-3 7.43523E-3 1.26675E-3
1.38152E-3 1.91987E-3 9.90437E-4

LAMBDA 1.00000E2
RSS 5.93639E2
NPHI 5.93639E2

par
1.89387E3 1.74967E3 3.74296E2 1.33588E2 1.11368E2 1.13889E-3 1.38223E-3 1.99548E-3 2.89747E-3 5.18928E-3
9.86695E-4 1.18536E-3 1.86133E-3 2.97918E-3 5.89644E-3 1.57474E-3 2.44452E-3 4.03410E-3 7.32177E-3 1.14565E-3
1.25151E-3 1.76441E-3 8.87073E-4

LAMBDA 1.00000E1
RSS 4.90937E2
NPHI 4.90937E2

par
1.70522E3 1.56346E3 3.41359E2 1.10651E2 8.78527E1 9.48834E-4 1.16492E-3 1.73211E-3 2.59247E-3 4.88633E-3
8.13595E-4 9.87576E-4 1.60668E-3 2.67193E-3 5.60528E-3 1.33887E-3 2.15140E-3 3.70858E-3 7.11198E-3 9.54877E-4
1.04690E-3 1.51658E-3 7.26006E-4

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LAMBDA      1.00000E0
RSS         9.76380E1
NPHI        9.76380E1

par
   1.59712E3     1.40844E3     3.69693E2     8.45171E1     4.97662E1     1.72996E-4    2.64899E-4    6.00969E-4    1.28479E-3    3.57640E-3
   1.14284E-4    1.77930E-4    5.19303E-4    1.35224E-3    4.25639E-3    3.48102E-4    8.93500E-4    2.27775E-3    6.17382E-3    1.75780E-4
   2.05865E-4    4.62936E-4    8.01980E-5


LAMBDA      1.00000E-1
RSS         7.31704E1
NPHI        7.31704E1

par
   2.95996E3     2.53369E3     7.70795E2     1.57623E2     9.56436E1     1.61449E-4    2.29745E-4    4.13707E-4    8.26750E-4    2.59569E-3
   1.25190E-4    1.76884E-4    3.68703E-4    8.70067E-4    3.38578E-3    2.89326E-4    6.24124E-4    1.59123E-3    5.23713E-3    1.63065E-4
   1.94364E-4    3.37748E-4    1.01082E-4


LAMBDA      1.00000E-2
RSS         7.03678E1
NPHI        7.03678E1

par
   3.97866E3     3.32369E3     1.14399E3     2.22121E2     1.27116E2     1.55275E-4    2.22883E-4    4.17749E-4    8.47117E-4    2.60450E-3
   1.22556E-4    1.72012E-4    3.69645E-4    8.91527E-4    3.35842E-3    2.82350E-4    6.29396E-4    1.61040E-3    5.13295E-3    1.56812E-4
   1.88407E-4    3.36671E-4    1.03007E-4


LAMBDA      1.00000E-3
RSS         7.02833E1
NPHI        7.02833E1

par
   4.19916E3     3.47992E3     1.25031E3     2.40326E2     1.31682E2     1.54598E-4    2.21958E-4    4.16636E-4    8.45044E-4    2.60019E-3
   1.21967E-4    1.71288E-4    3.68630E-4    8.89345E-4    3.35027E-3    2.81275E-4    6.27496E-4    1.60773E-3    5.11887E-3    1.56129E-4
   1.87629E-4    3.35737E-4    1.02528E-4


LAMBDA      1.00000E-4
RSS         7.02829E1
NPHI        7.02829E1

par
   4.20596E3     3.48446E3     1.25793E3     2.42140E2     1.31816E2     1.54548E-4    2.21888E-4    4.16479E-4    8.44662E-4    2.59959E-3
   1.21929E-4    1.71234E-4    3.68492E-4    8.88943E-4    3.34961E-3    2.81175E-4    6.27294E-4    1.60748E-3    5.11736E-3    1.56079E-4
   1.87570E-4    3.35611E-4    1.02496E-4

RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN 0.00001
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RESULTS

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

SUM OF SQUARES 70.282949
ORTHOGONALITY OFFSET..... 0.009249
MEAN SQUARE RESIDUALS 0.341179

	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 2	4.20596E3	1.28877E3	3.26355E0	0.31
N 3	3.48446E3	8.16696E2	4.26653E0	0.23
N 4	1.25793E3	3.45296E2	3.64306E0	0.27
N 5	2.42140E2	8.41553E1	2.87730E0	0.35
N 6	1.31816E2	5.07636E1	2.59666E0	0.39
qRV SPR 2	1.54548E-4	2.56858E-5	6.01689E0	0.17
qRV SPR 3	2.21888E-4	3.64816E-5	6.08220E0	0.16
qRV SPR 4	4.16479E-4	6.85936E-5	6.07169E0	0.16
qRV SPR 5	8.44662E-4	1.40676E-4	6.00432E0	0.17
qRV SPR 6	2.59959E-3	4.35298E-4	5.97199E0	0.17
qRV FAL 2	1.21929E-4	2.02644E-5	6.01689E0	0.17
qRV FAL 3	1.71234E-4	2.81533E-5	6.08220E0	0.16
qRV FAL 4	3.68492E-4	6.06901E-5	6.07169E0	0.16
qRV FAL 5	8.88943E-4	1.48051E-4	6.00432E0	0.17
qRV FAL 6	3.34961E-3	5.69391E-4	5.88280E0	0.17
qCM CPE 3	2.81175E-4	4.79650E-5	5.86209E0	0.17
qCM CPE 4	6.27294E-4	1.07260E-4	5.84832E0	0.17
qCM CPE 5	1.60748E-3	2.76494E-4	5.81378E0	0.17
qCM CPE 6	5.11736E-3	8.74642E-4	5.85080E0	0.17
qMA SPR 2	1.56079E-4	2.59401E-5	6.01689E0	0.17
qMA SPR 3	1.87570E-4	3.08391E-5	6.08220E0	0.16
qMA SPR 4	3.35611E-4	5.52747E-5	6.07169E0	0.16
qMA FAL 2	1.02496E-4	1.70347E-5	6.01689E0	0.17

CATCHABILITY ESTIMATES IN ORIGINAL UNITS

	ESTIMATE	STD. ERR.	C.V.
qRV SPR 2	8.74096E-5	1.45274E-5	0.17
qRV SPR 3	1.49939E-4	2.46520E-5	0.16
qRV SPR 4	2.35065E-4	3.87149E-5	0.16
qRV SPR 5	2.95769E-4	4.92593E-5	0.17
qRV SPR 6	2.94784E-4	4.93610E-5	0.17
qRV FAL 2	7.19081E-5	1.19511E-5	0.17
qRV FAL 3	1.81889E-4	2.99051E-5	0.16
qRV FAL 4	3.15753E-4	5.20041E-5	0.16
qRV FAL 5	3.50539E-4	5.83811E-5	0.17
qRV FAL 6	6.01937E-4	1.02321E-4	0.17
qCM CPE 3	2.07458E-5	3.53898E-6	0.17
qCM CPE 4	3.25505E-5	5.56579E-6	0.17
qCM CPE 5	3.11461E-5	5.35729E-6	0.17
qCM CPE 6	3.20711E-5	5.48149E-6	0.17
qMA SPR 2	1.34957E-3	2.24296E-4	0.17
qMA SPR 3	8.07993E-4	1.32846E-4	0.16
qMA SPR 4	4.13473E-4	6.80984E-5	0.16
qMA FAL 2	4.32044E-4	7.18053E-5	0.17

CORRELATION BETWEEN PARAMETERS ESTIMATED

1.00	0.07	0.04	0.02	0.02	-0.15	-0.01	-0.01	-0.01	-0.00	-0.15	-0.01	-0.01	-0.01	-0.00	-0.01	-0.00	-0.00	-0.00	-0.15	-0.01	-0.01	-0.15
0.07	1.00	0.05	0.03	0.02	-0.12	-0.11	-0.01	-0.01	-0.01	-0.12	-0.11	-0.01	-0.01	-0.00	-0.01	-0.01	-0.00	-0.00	-0.12	-0.11	-0.01	-0.12
0.04	0.05	1.00	0.04	0.03	-0.07	-0.07	-0.13	-0.01	-0.01	-0.07	-0.07	-0.13	-0.01	-0.00	-0.10	-0.01	-0.01	-0.01	-0.07	-0.07	-0.13	-0.07
0.02	0.03	0.04	1.00	0.01	-0.04	-0.04	-0.06	-0.18	-0.06	-0.04	-0.04	-0.06	-0.18	-0.06	-0.05	-0.11	-0.04	-0.10	-0.04	-0.04	-0.06	-0.04
0.02	0.02	0.03	0.01	1.00	-0.03	-0.03	-0.05	-0.11	-0.23	-0.03	-0.03	-0.05	-0.11	-0.05	-0.04	-0.08	-0.17	-0.09	-0.03	-0.03	-0.05	-0.03
-0.15	-0.12	-0.07	-0.04	-0.03	1.00	0.02	0.01	0.01	0.01	0.04	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.04	0.02	0.01	0.04
-0.01	-0.11	-0.07	-0.04	-0.03	0.02	1.00	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02
-0.01	-0.01	-0.13	-0.06	-0.05	0.01	0.01	1.00	0.02	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01
-0.01	-0.01	-0.01	-0.18	-0.11	0.01	0.01	0.02	1.00	0.04	0.01	0.01	0.02	0.04	0.02	0.01	0.03	0.02	0.03	0.01	0.01	0.02	0.01
-0.00	-0.01	-0.01	-0.06	-0.23	0.01	0.01	0.01	0.04	1.00	0.01	0.01	0.01	0.04	0.02	0.01	0.02	0.04	0.03	0.01	0.01	0.01	0.01
-0.15	-0.12	-0.07	-0.04	-0.03	0.04	0.02	0.01	0.01	0.01	1.00	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.04	0.02	0.01	0.04
-0.01	-0.11	-0.07	-0.04	-0.03	0.02	0.02	0.01	0.01	0.01	0.02	1.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02
-0.01	-0.01	-0.13	-0.06	-0.05	0.01	0.01	0.02	0.02	0.01	0.01	0.01	1.00	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01
-0.01	-0.01	-0.01	-0.18	-0.11	0.01	0.01	0.02	0.04	0.04	0.01	0.01	0.02	1.00	0.02	0.01	0.03	0.02	0.03	0.01	0.01	0.02	0.01
-0.00	-0.00	-0.00	-0.06	-0.05	0.00	0.00	0.01	0.02	0.02	0.00	0.00	0.01	0.02	1.00	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00
-0.01	-0.01	-0.10	-0.05	-0.04	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	1.00	0.01	0.01	0.01	0.01	0.01	0.02	0.01
-0.00	-0.01	-0.01	-0.11	-0.08	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.01	0.03	0.01	0.01	1.00	0.02	0.02	0.01	0.01	0.01	0.01
-0.00	-0.00	-0.01	-0.04	-0.17	0.01	0.01	0.01	0.02	0.04	0.01	0.01	0.01	0.02	0.01	0.01	0.02	1.00	0.02	0.01	0.01	0.01	0.01
-0.00	-0.00	-0.01	-0.10	-0.09	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.03	0.01	0.01	0.02	0.02	1.00	0.01	0.01	0.01	0.01
-0.15	-0.12	-0.07	-0.04	-0.03	0.04	0.02	0.01	0.01	0.01	0.04	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.01	1.00	0.02	0.01	0.04
-0.01	-0.11	-0.07	-0.04	-0.03	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.02	1.00	0.01	0.02
-0.01	-0.01	-0.13	-0.06	-0.05	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	1.00	0.01
-0.15	-0.12	-0.07	-0.04	-0.03	0.04	0.02	0.01	0.01	0.01	0.04	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.04	0.02	0.01	1.00

CORRELATION BETWEEN PARAMETERS ESTIMATED (SYMBOLIC FORM)

```
N 2       * . . . . . . . . . . . . . . . . . . . .
N 3       . * . . . . . . . . . . . . . . . . . . .
N 4       . . * . . . . . . . . . . . . . . . . . .
N 5       . . . * . . . . . . . . . . . . . . . . .
N 6       . . . . * . . . . - . . . . . . . . . . .
qRV SPR 2 . . . . . * . . . . . . . . . . . . . . .
qRV SPR 3 . . . . . . * . . . . . . . . . . . . . .
qRV SPR 4 . . . . . . . * . . . . . . . . . . . . .
qRV SPR 5 . . . . . . . . * . . . . . . . . . . . .
qRV SPR 6 . . . . - . . . . * . . . . . . . . . . .
qRV FAL 2 . . . . . . . . . . * . . . . . . . . . .
qRV FAL 3 . . . . . . . . . . . * . . . . . . . . .
qRV FAL 4 . . . . . . . . . . . . * . . . . . . . .
qRV FAL 5 . . . . . . . . . . . . . * . . . . . . .
qRV FAL 6 . . . . . . . . . . . . . . * . . . . . .
qCM CPE 3 . . . . . . . . . . . . . . . * . . . . .
qCM CPE 4 . . . . . . . . . . . . . . . . * . . . .
qCM CPE 5 . . . . . . . . . . . . . . . . . * . . .
qCM CPE 6 . . . . . . . . . . . . . . . . . . * . .
qMA SPR 2 . . . . . . . . . . . . . . . . . . . * .
qMA SPR 3 . . . . . . . . . . . . . . . . . . . . *
qMA SPR 4 . . . . . . . . . . . . . . . . . . . . .
qMA FAL 2 . . . . . . . . . . . . . . . . . . . . .
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SYMBOLS:

=	LARGE NEGATIVE CORRELATION	whenever	-1 <= R < -L
-	MODERATE NEGATIVE CORRELATION	whenever	-L <= R < -M
.	SMALL CORRELATION	whenever	-M <= R <= +M
+	MODERATE POSITIVE CORRELATION	whenever	+M < R <= +L
*	LARGE POSITIVE CORRELATION	whenever	+L < R <= +1

Where R is the estimated correlation, M is 0.2 and L is 0.5

SUMMMARY OF RESIDUALS

Index 1 RV SPR 2
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.5889	0.3419	1.0000	0.2470	0.4229	9107.686
1983	0.5478	-0.2542	1.0000	0.8020	1.3731	5017.903
1984	0.6021	-0.3564	1.0000	0.9585	1.6410	4530.561
1985	-0.8656	-0.0205	1.0000	-0.8450	-1.4467	6338.924
1986	-0.5388	-0.4749	1.0000	-0.0639	-0.1094	4024.441
1987	0.1205	-0.0640	1.0000	0.1844	0.3158	6069.614
1988	0.6215	0.2323	1.0000	0.3892	0.6664	8162.674
1989	0.1382	1.0107	1.0000	-0.8726	-1.4939	17778.403
1990	-1.0888	-0.8240	1.0000	-0.2648	-0.4533	2838.446
1991	-0.9938	-0.9142	1.0000	-0.0797	-0.1364	2593.643
1992	-0.8998	-0.4251	1.0000	-0.4747	-0.8127	4229.777
1993	-0.1232	-0.3994	1.0000	0.2761	0.4728	4339.919
1994	-0.6875	-0.4307	1.0000	-0.2567	-0.4395	4205.957

Partial variance for this index is 0.318369

Index 2 RV SPR 3
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.2690	-0.0404	1.0000	-0.2286	-0.3913	4328.315
1983	0.2093	0.3203	1.0000	-0.1110	-0.1900	6208.067
1984	0.5287	-0.3042	1.0000	0.8329	1.4260	3324.723
1985	-0.0829	-0.3099	1.0000	0.2271	0.3887	3305.752
1986	-0.0435	0.0675	1.0000	-0.1110	-0.1900	4821.603
1987	-0.3296	-0.3365	1.0000	0.0069	0.0119	3218.928
1988	-0.0653	0.0576	1.0000	-0.1229	-0.2105	4773.935
1989	0.1562	0.3721	1.0000	-0.2159	-0.3696	6538.258
1990	0.6750	1.1512	1.0000	-0.4762	-0.8153	14250.795
1991	-0.6445	-0.7455	1.0000	0.1010	0.1729	2138.431
1992	-1.0352	-0.9110	1.0000	-0.1241	-0.2125	1812.231
1993	0.1688	-0.3488	1.0000	0.5176	0.8861	3179.834
1994	-0.5531	-0.2573	1.0000	-0.2958	-0.5064	3484.457

Partial variance for this index is 0.127256

Index 3 RV SPR 4
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.2065	0.1047	1.0000	0.1017	0.1741	2666.215
1983	0.1275	-0.1502	1.0000	0.2777	0.4755	2066.125
1984	0.2722	0.2059	1.0000	0.0663	0.1135	2950.034
1985	0.1640	-0.4059	1.0000	0.5699	0.9757	1600.054
1986	-0.3774	-0.5401	1.0000	0.1628	0.2787	1399.031
1987	-0.6320	-0.1880	1.0000	-0.4440	-0.7601	1989.527
1988	-0.4637	-0.1354	1.0000	-0.3283	-0.5620	2097.057
1989	0.1131	0.0807	1.0000	0.0324	0.0555	2602.887
1990	0.1056	0.4904	1.0000	-0.3848	-0.6587	3920.716
1991	0.9622	1.2722	1.0000	-0.3100	-0.5307	8568.496
1992	-0.7010	-0.9750	1.0000	0.2740	0.4691	905.681
1993	-0.5367	-0.8718	1.0000	0.3351	0.5737	1004.165
1994	-0.9993	-0.6464	1.0000	-0.3529	-0.6042	1257.935

Partial variance for this index is 0.111337

Index 4 RV SPR 5
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 5
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.9031	0.3387	1.0000	0.5644	0.9663	1661.086
1983	0.0200	-0.0302	1.0000	0.0502	0.0860	1148.683
1984	-0.6097	-0.4777	1.0000	-0.1320	-0.2260	734.282
1985	0.6593	-0.1124	1.0000	0.7717	1.3211	1058.027
1986	-1.5543	-1.0524	1.0000	-0.5020	-0.8594	413.320
1987	-1.0064	-1.0609	1.0000	0.0545	0.0934	409.797
1988	-0.4785	-0.6381	1.0000	0.1596	0.2733	625.422
1989	-1.3579	-0.3259	1.0000	-1.0320	-1.7668	854.615
1990	-0.7423	-0.3729	1.0000	-0.3694	-0.6324	815.430
1991	-0.2681	0.1257	1.0000	-0.3938	-0.6742	1342.426
1992	1.3194	1.0099	1.0000	0.3095	0.5298	3250.263
1993	-1.3586	-1.3610	1.0000	0.0024	0.0041	303.568
1994	-1.0702	-1.5871	1.0000	0.5168	0.8848	242.140

Partial variance for this index is 0.250284

Index 5 RV SPR 6
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 6
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.0320	-0.8394	1.0000	0.8713	1.4917	166.176
1983	0.4674	0.7161	1.0000	-0.2487	-0.4258	787.220
1984	-0.7598	-0.0575	1.0000	-0.7023	-1.2024	363.176
1985	-0.1770	-0.6257	1.0000	0.4487	0.7681	205.765
1986	-0.9022	-0.2614	1.0000	-0.6409	-1.0972	296.192
1987	-2.3330	-1.2322	1.0000	-1.1008	-1.8845	112.188
1988	-0.2650	-1.5112	1.0000	1.2463	2.1336	84.873
1989	-0.3919	-0.9778	1.0000	0.5859	1.0031	144.688
1990	-1.2530	-0.2708	1.0000	-0.9823	-1.6817	293.427
1991	-1.5654	-0.3228	1.0000	-1.2426	-2.1273	278.537
1992	0.6627	-0.1561	1.0000	0.8189	1.4019	329.069
1993	1.4429	0.7752	1.0000	0.6677	1.1431	835.128
1994	-0.7922	-1.0710	1.0000	0.2788	0.4773	131.816

Partial variance for this index is 0.745369

Index 6 RV FAL 2
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.0489	0.1048	1.0000	-0.0559	-0.0957	9107.686
1983	0.1720	-0.4913	1.0000	0.6633	1.1356	5017.903
1984	1.0348	-0.5935	1.0000	1.6282	2.7876	4530.561
1985	-0.4297	-0.2576	1.0000	-0.1721	-0.2946	6338.924
1986	-0.4448	-0.7119	1.0000	0.2671	0.4573	4024.441
1987	-0.6726	-0.3010	1.0000	-0.3716	-0.6361	6069.614
1988	0.0156	-0.0047	1.0000	0.0203	0.0348	8162.674
1989	1.1964	0.7737	1.0000	0.4227	0.7237	17778.403
1990	-0.3501	-1.0611	1.0000	0.7109	1.2171	2838.446
1991	-3.0045	-1.1513	1.0000	-1.8533	-3.1728	2593.643
1992	-1.4225	-0.6622	1.0000	-0.7603	-1.3017	4229.777
1993	-0.7098	-0.6365	1.0000	-0.0734	-0.1256	4339.919
1994	-1.0940	-0.6678	1.0000	-0.4262	-0.7296	4205.957

Partial variance for this index is 0.701014

Index 7 RV FAL 3
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-1.0222	-0.2995	1.0000	-0.7226	-1.2372	4328.315
1983	1.0844	0.0611	1.0000	1.0233	1.7519	6208.067
1984	-0.0841	-0.5633	1.0000	0.4793	0.8205	3324.723
1985	-0.9250	-0.5691	1.0000	-0.3560	-0.6094	3305.752
1986	-0.1547	-0.1916	1.0000	0.0369	0.0632	4821.603
1987	-0.7737	-0.5957	1.0000	-0.1780	-0.3048	3218.928
1988	0.2203	-0.2016	1.0000	0.4218	0.7222	4773.935
1989	0.7483	0.1129	1.0000	0.6354	1.0878	6538.258
1990	0.8112	0.8921	1.0000	-0.0809	-0.1386	14250.795
1991	-1.0640	-1.0047	1.0000	-0.0593	-0.1015	2138.431
1992	-2.0109	-1.1702	1.0000	-0.8407	-1.4393	1812.231
1993	-0.8589	-0.6079	1.0000	-0.2510	-0.4297	3179.834
1994	-0.6246	-0.5164	1.0000	-0.1082	-0.1852	3484.457

Partial variance for this index is 0.284253

Index 8 RV FAL 4
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.4450	-0.0177	1.0000	-0.4273	-0.7315	2666.215
1983	1.0597	-0.2727	1.0000	1.3324	2.2811	2066.125
1984	-0.0060	0.0835	1.0000	-0.0895	-0.1532	2950.034
1985	-0.4170	-0.5283	1.0000	0.1113	0.1906	1600.054
1986	-0.1160	-0.6626	1.0000	0.5465	0.9357	1399.031
1987	-0.2702	-0.3104	1.0000	0.0403	0.0689	1989.527
1988	-0.3564	-0.2578	1.0000	-0.0986	-0.1687	2097.057
1989	0.1136	-0.0417	1.0000	0.1554	0.2660	2602.887
1990	0.4593	0.3679	1.0000	0.0914	0.1564	3920.716
1991	0.6511	1.1498	1.0000	-0.4987	-0.8537	8568.496
1992	-1.3542	-1.0974	1.0000	-0.2568	-0.4397	905.681
1993	-1.8117	-0.9942	1.0000	-0.8175	-1.3995	1004.165
1994	-0.8578	-0.7689	1.0000	-0.0889	-0.1522	1257.935

Partial variance for this index is 0.282501

Index 9 RV FAL 5
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 5
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.1845	0.3897	1.0000	-0.2052	-0.3514	1661.086
1983	1.0849	0.0209	1.0000	1.0640	1.8216	1148.683
1984	-1.0439	-0.4266	1.0000	-0.6173	-1.0568	734.282
1985	0.0127	-0.0613	1.0000	0.0740	0.1267	1058.027
1986	-0.6349	-1.0013	1.0000	0.3664	0.6273	413.320
1987	-0.1691	-1.0098	1.0000	0.8408	1.4394	409.797
1988	-0.4281	-0.5871	1.0000	0.1589	0.2721	625.422
1989	0.2919	-0.2748	1.0000	0.5667	0.9703	854.615
1990	-0.2940	-0.3218	1.0000	0.0277	0.0475	815.430
1991	0.4566	0.1768	1.0000	0.2798	0.4791	1342.426
1992	0.4717	1.0610	1.0000	-0.5893	-1.0089	3250.263
1993	-2.2883	-1.3099	1.0000	-0.9784	-1.6751	303.568
1994	-2.5240	-1.5360	1.0000	-0.9881	-1.6916	242.140

Partial variance for this index is 0.435781

Index 10 RV FAL 6
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 6
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.7036	-0.5859	1.0000	-0.1177	-0.2015	166.176
1983	0.3223	0.9696	1.0000	-0.6473	-1.1082	787.220
1984	0.3833	0.1960	1.0000	0.1873	0.3207	363.176
1985	0.2021	-0.3722	1.0000	0.5743	0.9832	205.765
1986	0.1932	-0.0079	1.0000	0.2011	0.3443	296.192
1987	-0.7370	-0.9787	1.0000	0.2418	0.4139	112.188
1988	-1.0804	-1.2578	1.0000	0.1773	0.3036	84.873
1989	-0.4908	-0.7243	1.0000	0.2335	0.3998	144.688
1990	-0.0334	-0.0173	1.0000	-0.0161	-0.0276	293.427
1991	0.4366	-0.0694	1.0000	0.5060	0.8662	278.537
1992	-0.8219	0.0974	1.0000	-0.9192	-1.5737	329.069
1993	0.6078	1.0287	1.0000	-0.4209	-0.7206	835.128

Partial variance for this index is 0.210871

Index 12 CM CPE 3
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.1992	-0.1507	1.0000	0.3498	0.5989	3059.066
1983	0.5996	0.2080	1.0000	0.3916	0.6704	4378.883
1984	-0.3012	-0.4109	1.0000	0.1097	0.1878	2358.202
1985	-0.3948	-0.4724	1.0000	0.0776	0.1328	2217.416
1986	0.0914	-0.1058	1.0000	0.1973	0.3377	3199.328
1987	-1.1725	-0.3063	1.0000	-0.8661	-1.4829	2618.053
1988	-0.2271	0.0064	1.0000	-0.2335	-0.3998	3579.341
1989	0.0371	0.3641	1.0000	-0.3270	-0.5598	5118.420
1990	0.9342	1.1444	1.0000	-0.2103	-0.3600	11169.786
1991	-0.4630	-0.9077	1.0000	0.4447	0.7613	1434.864
1992	-1.2629	-0.9549	1.0000	-0.3080	-0.5273	1368.670
1993	-0.1658	-0.5400	1.0000	0.3743	0.6407	2072.447

Partial variance for this index is 0.160535

Index 13 CM CPE 4
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.0566	0.1227	1.0000	-0.0660	-0.1130	1802.201
1983	-0.0067	-0.2137	1.0000	0.2070	0.3544	1287.381
1984	0.0374	0.1462	1.0000	-0.1088	-0.1863	1845.121
1985	-0.4214	-0.5979	1.0000	0.1765	0.3021	876.743
1986	-0.6709	-0.6824	1.0000	0.0116	0.0198	805.648
1987	-0.4864	-0.3019	1.0000	-0.1846	-0.3160	1178.772
1988	-0.5855	-0.1413	1.0000	-0.4442	-0.7604	1384.122
1989	-0.0848	-0.0345	1.0000	-0.0503	-0.0861	1540.034
1990	0.5727	0.4115	1.0000	0.1612	0.2760	2405.579
1991	1.0983	1.2359	1.0000	-0.1376	-0.2356	5486.355
1992	-1.1386	-1.0627	1.0000	-0.0759	-0.1300	550.840
1993	-0.5793	-1.0905	1.0000	0.5112	0.8752	535.734

Partial variance for this index is 0.059335

Index 14 CM CPE 5
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 5
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.3112	0.6319	1.0000	-0.3208	-0.5491	1170.274
1983	0.2785	0.0922	1.0000	0.1863	0.3190	682.169
1984	-0.2984	-0.4037	1.0000	0.1053	0.1803	415.449
1985	0.0846	-0.0389	1.0000	0.1235	0.2114	598.384
1986	-0.9130	-0.9910	1.0000	0.0780	0.1336	230.921
1987	-1.0154	-1.1034	1.0000	0.0880	0.1506	206.366
1988	-0.5541	-0.6388	1.0000	0.0847	0.1450	328.405
1989	-0.4197	-0.1698	1.0000	-0.2500	-0.4279	524.955
1990	-0.3000	-0.2188	1.0000	-0.0811	-0.1389	499.824
1991	0.2515	0.1472	1.0000	0.1043	0.1786	720.755
1992	1.1627	1.0497	1.0000	0.1130	0.1935	1777.264
1993	-1.3371	-1.1058	1.0000	-0.2314	-0.3961	205.889

Partial variance for this index is 0.030889

Index 15 CM CPE 6
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 6
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.6628	-0.5417	1.0000	-0.1211	-0.2073	113.686
1983	0.8759	0.8943	1.0000	-0.0184	-0.0315	477.910
1984	0.0718	0.1228	1.0000	-0.0510	-0.0873	220.941
1985	-0.3905	-0.5537	1.0000	0.1632	0.2793	112.329
1986	-0.2196	-0.1568	1.0000	-0.0628	-0.1075	167.056
1987	-1.0609	-1.1158	1.0000	0.0549	0.0940	64.029
1988	-1.2750	-1.3013	1.0000	0.0263	0.0450	53.187
1989	-0.8145	-0.8268	1.0000	0.0122	0.0210	85.485
1990	-0.0431	-0.0915	1.0000	0.0484	0.0828	178.335
1991	-0.3245	-0.1200	1.0000	-0.2045	-0.3500	173.310
1992	-0.0031	-0.0730	1.0000	0.0699	0.1196	181.663
1993	1.0237	0.9408	1.0000	0.0829	0.1419	500.661

Partial variance for this index is 0.010065

Index 16 MA SPR 2
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.2027	0.3517	1.0000	-0.5545	-0.9492	9107.686
1983	0.7645	-0.2444	1.0000	1.0089	1.7272	5017.903
1984	-0.4693	-0.3465	1.0000	-0.1227	-0.2101	4530.561
1985	-0.8164	-0.0107	1.0000	-0.8057	-1.3794	6338.924
1986	-0.9872	-0.4650	1.0000	-0.5222	-0.8940	4024.441
1987	-0.2117	-0.0541	1.0000	-0.1576	-0.2698	6069.614
1988	0.2726	0.2422	1.0000	0.0304	0.0520	8162.674
1989	1.0720	1.0206	1.0000	0.0515	0.0881	17778.403
1990	-0.2271	-0.8141	1.0000	0.5870	1.0050	2838.446
1991	-0.8874	-0.9043	1.0000	0.0169	0.0290	2593.643
1992	-0.3087	-0.4152	1.0000	0.1065	0.1824	4229.777
1993	-0.1082	-0.3895	1.0000	0.2813	0.4817	4339.919
1994	-0.3407	-0.4209	1.0000	0.0802	0.1372	4205.957

Partial variance for this index is 0.233092

Index 17 MA SPR 3
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.2313	-0.2084	1.0000	-0.0229	-0.0392	4328.315
1983	0.2131	0.1522	1.0000	0.0609	0.1042	6208.067
1984	-0.6402	-0.4722	1.0000	-0.1680	-0.2876	3324.723
1985	-0.4329	-0.4779	1.0000	0.0450	0.0771	3305.752
1986	-1.5803	-0.1005	1.0000	-1.4798	-2.5335	4821.603
1987	-0.6415	-0.5046	1.0000	-0.1369	-0.2345	3218.928
1988	-0.5397	-0.1104	1.0000	-0.4293	-0.7350	4773.935
1989	0.4236	0.2041	1.0000	0.2196	0.3759	6538.258
1990	1.4171	0.9832	1.0000	0.4339	0.7428	14250.795
1991	-0.5282	-0.9135	1.0000	0.3853	0.6596	2138.431
1992	-0.1850	-1.0790	1.0000	0.8940	1.5306	1812.231
1993	-0.1795	-0.5168	1.0000	0.3373	0.5775	3179.834
1994	-0.5643	-0.4253	1.0000	-0.1390	-0.2380	3484.457

Partial variance for this index is 0.319448

Index 18 MA SPR 4
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.0715	-0.1111	1.0000	0.0397	0.0679	2666.215
1983	-0.8998	-0.3661	1.0000	-0.5337	-0.9136	2066.125
1984	-0.3537	-0.0100	1.0000	-0.3437	-0.5884	2950.034
1985	-0.5768	-0.6218	1.0000	0.0450	0.0770	1600.054
1986	-1.0620	-0.7560	1.0000	-0.3059	-0.5238	1399.031
1987	-1.5673	-0.4039	1.0000	-1.1634	-1.9918	1989.527
1988	0.1062	-0.3513	1.0000	0.4574	0.7831	2097.057
1989	-0.9895	-0.1352	1.0000	-0.8543	-1.4627	2602.887
1990	0.7621	0.2745	1.0000	0.4877	0.8349	3920.716
1991	1.4068	1.0563	1.0000	0.3505	0.6000	8568.496
1992	-0.6394	-1.1909	1.0000	0.5514	0.9441	905.681
1993	0.1629	-1.0876	1.0000	1.2506	2.1410	1004.165
1994	-0.8435	-0.8623	1.0000	0.0188	0.0322	1257.935

Partial variance for this index is 0.428402

Index 19 MA FAL 2
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.2933	-0.0688	1.0000	0.3621	0.6200	9107.686
1983	-0.5860	-0.6649	1.0000	0.0789	0.1351	5017.903
1984	-1.8679	-0.7671	1.0000	-1.1009	-1.8847	4530.561
1985	-2.5058	-0.4312	1.0000	-2.0746	-3.5517	6338.924
1986	-2.3086	-0.8855	1.0000	-1.4230	-2.4363	4024.441
1987	-1.2989	-0.4746	1.0000	-0.8243	-1.4112	6069.614
1988	-0.5691	-0.1784	1.0000	-0.3907	-0.6689	8162.674
1989	1.5812	0.6001	1.0000	0.9812	1.6798	17778.403
1990	-0.4455	-1.2347	1.0000	0.7892	1.3512	2838.446
1991	0.7729	-1.3249	1.0000	2.0977	3.5914	2593.643
1992	-0.0036	-0.8358	1.0000	0.8322	1.4247	4229.777
1993	-0.7406	-0.8101	1.0000	0.0695	0.1190	4339.919
1994	-0.2387	-0.8414	1.0000	0.6027	1.0318	4205.957

Partial variance for this index is 1.327139

Standardized residuals by index & yr; with row/column/grand means

■	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994*******	
1 ■	0.4229	1.3731	1.6410	-1.4467	-0.1094	0.3158	0.6664	-1.4939	-0.4533	-0.1364	-0.8127	0.4728	-0.4395	0.0000
2 ■	-0.3913	-0.1900	1.4260	0.3887	-0.1900	0.0119	-0.2105	-0.3696	-0.8153	0.1729	-0.2125	0.8861	-0.5064	0.0000
3 ■	0.1741	0.4755	0.1135	0.9757	0.2787	-0.7601	-0.5620	0.0555	-0.6587	-0.5307	0.4691	0.5737	-0.6042	0.0000
4 ■	0.9663	0.0860	-0.2260	1.3211	-0.8594	0.0934	0.2733	-1.7668	-0.6324	-0.6742	0.5298	0.0041	0.8848	0.0000
5 ■	1.4917	-0.4258	-1.2024	0.7681	-1.0972	-1.8845	2.1336	1.0031	-1.6817	-2.1273	1.4019	1.1431	0.4773	0.0000
6 ■	-0.0957	1.1356	2.7876	-0.2946	0.4573	-0.6361	0.0348	0.7237	1.2171	-3.1728	-1.3017	-0.1256	-0.7296	0.0000
7 ■	-1.2372	1.7519	0.8205	-0.6094	0.0632	-0.3048	0.7222	1.0878	-0.1386	-0.1015	-1.4393	-0.4297	-0.1852	0.0000
8 ■	-0.7315	2.2811	-0.1532	0.1906	0.9357	0.0689	-0.1687	0.2660	0.1564	-0.8537	-0.4397	-1.3995	-0.1522	0.0000
9 ■	-0.3514	1.8216	-1.0568	0.1267	0.6273	1.4394	0.2721	0.9703	0.0475	0.4791	-1.0089	-1.6751	-1.6916	0.0000
10 ■	-0.2015	-1.1082	0.3207	0.9832	0.3443	0.4139	0.3036	0.3998	-0.0276	0.8662	-1.5737	-0.7206	-99.0000	0.0000
12 ■	0.5989	0.6704	0.1878	0.1328	0.3377	-1.4829	-0.3998	-0.5598	-0.3600	0.7613	-0.5273	0.6407	-99.0000	0.0000
13 ■	-0.1130	0.3544	-0.1863	0.3021	0.0198	-0.3160	-0.7604	-0.0861	0.2760	-0.2356	-0.1300	0.8752	-99.0000	0.0000
14 ■	-0.5491	0.3190	0.1803	0.2114	0.1336	0.1506	0.1450	-0.4279	-0.1389	0.1786	0.1935	-0.3961	-99.0000	0.0000
15 ■	-0.2073	-0.0315	-0.0873	0.2793	-0.1075	0.0940	0.0450	0.0210	0.0828	-0.3500	0.1196	0.1419	-99.0000	0.0000
16 ■	-0.9492	1.7272	-0.2101	-1.3794	-0.8940	-0.2698	0.0520	0.0881	1.0050	0.0290	0.1824	0.4817	0.1372	0.0000
17 ■	-0.0392	0.1042	-0.2876	0.0771	-2.5335	-0.2345	-0.7350	0.3759	0.7428	0.6596	1.5306	0.5775	-0.2380	0.0000
18 ■	0.0679	-0.9136	-0.5884	0.0770	-0.5238	-1.9918	0.7831	-1.4627	0.8349	0.6000	0.9441	2.1410	0.0322	0.0000
19 ■	0.6200	0.1351	-1.8847	-3.5517	-2.4363	-1.4112	-0.6689	1.6798	1.3512	3.5914	1.4247	0.1190	1.0318	0.0000
** ■	-0.0291	0.5314	0.0886	-0.0804	-0.3085	-0.3724	0.1070	0.0280	0.0448	-0.0469	-0.0361	0.1839	-0.1526	0.0000

-99 in the above table indicates a missing value

Percent of total sum of squares by index & yr; with row/column sums

■	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994*******	
1 ■	0.09	0.92	1.31	1.02	0.01	0.05	0.22	1.08	0.10	0.01	0.32	0.11	0.09	5.31
2 ■	0.07	0.02	0.99	0.07	0.02	0.00	0.02	0.07	0.32	0.01	0.02	0.38	0.12	2.12
3 ■	0.01	0.11	0.01	0.46	0.04	0.28	0.15	0.00	0.21	0.14	0.11	0.16	0.18	1.86
4 ■	0.45	0.00	0.02	0.85	0.36	0.00	0.04	1.52	0.19	0.22	0.14	0.00	0.38	4.17
5 ■	1.08	0.09	0.70	0.29	0.58	1.72	2.21	0.49	1.37	2.20	0.95	0.63	0.11	12.43
6 ■	0.00	0.63	3.77	0.04	0.10	0.20	0.00	0.25	0.72	4.89	0.82	0.01	0.26	11.69
7 ■	0.74	1.49	0.33	0.18	0.00	0.05	0.25	0.57	0.01	0.01	1.01	0.09	0.02	4.74
8 ■	0.26	2.53	0.01	0.02	0.42	0.00	0.01	0.03	0.01	0.35	0.09	0.95	0.01	4.71
9 ■	0.06	1.61	0.54	0.01	0.19	1.01	0.04	0.46	0.00	0.11	0.49	1.36	1.39	7.27
10 ■	0.02	0.60	0.05	0.47	0.06	0.08	0.04	0.08	0.00	0.36	1.20	0.25	-99.00	3.22
12 ■	0.17	0.22	0.02	0.01	0.06	1.07	0.08	0.15	0.06	0.28	0.13	0.20	-99.00	2.45
13 ■	0.01	0.06	0.02	0.04	0.00	0.05	0.28	0.00	0.04	0.03	0.01	0.37	-99.00	0.91
14 ■	0.15	0.05	0.02	0.02	0.01	0.01	0.01	0.09	0.01	0.02	0.02	0.08	-99.00	0.47
15 ■	0.02	0.00	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.06	0.01	0.01	-99.00	0.15
16 ■	0.44	1.45	0.02	0.92	0.39	0.04	0.00	0.00	0.49	0.00	0.02	0.11	0.01	3.89
17 ■	0.00	0.01	0.04	0.00	3.12	0.03	0.26	0.07	0.27	0.21	1.14	0.16	0.03	5.33
18 ■	0.00	0.41	0.17	0.00	0.13	1.93	0.30	1.04	0.34	0.17	0.43	2.23	0.00	7.15
19 ■	0.19	0.01	1.72	6.12	2.88	0.97	0.22	1.37	0.89	6.26	0.99	0.01	0.52	22.13
** ■	3.77	10.18	9.74	10.57	8.37	7.48	4.13	7.28	5.04	15.33	7.90	7.11	3.12	100.00

-99 in the above table indicates a missing value

Partial variance (and proportion of total) by index

■	1	2	3	4	5	6	7	8	9	10	12
** ■	0.31836928	0.12725649	0.11133707	0.25028383	0.74536850	0.70101440	0.28425271	0.28250093	0.43578078	0.21087091	0.16053500
** ■	0.05274559	0.02108312	0.01844568	0.04146558	0.12348836	0.11614003	0.04709335	0.04680313	0.07219765	0.03493588	0.02659651

■	13	14	15	16	17	18	19**********	
** ■	0.05933531	0.03088912	0.01006538	0.23309198	0.31944850	0.42840167	1.32713939	6.03594125
** ■	0.00983033	0.00511753	0.00166757	0.03861734	0.05292439	0.07097512	0.21987281	1.00000000

STOCK NUMBERS (Jan 1) in thousands - GMCOD94

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	6129	5534	7742	4915	7413	9970	21715	3467	3168	5166	5301	5137	0
2	9108	5018	4531	6339	4024	6070	8163	17778	2838	2594	4230	4340	4206
3	4328	6208	3325	3306	4822	3219	4774	6538	14251	2138	1812	3180	3484
4	2666	2066	2950	1600	1399	1990	2097	2603	3921	8568	906	1004	1258
5	1661	1149	734	1058	413	410	625	855	815	1342	3250	304	242
6	166	787	363	206	296	112	85	145	293	279	329	835	132
7	547	284	250	214	156	132	58	98	182	152	134	65	291
1+	24606	21046	19896	17638	18524	21902	37517	31484	25469	20239	15962	14864	9613

Summaries for ages 2 5 3 5 4 5 5 5

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
2	17763	14441	11540	12303	10658	11688	15659	27774	21825	14643	10198	8827	9190
3	8656	9423	7009	5964	6634	5618	7496	9996	18987	12049	5968	4488	4985
4	4327	3215	3684	2658	1812	2399	2722	3458	4736	9911	4156	1308	1500
5	1661	1149	734	1058	413	410	625	855	815	1342	3250	304	242

FISHING MORTALITY - GMCOD94

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.18	0.21	0.12	0.07	0.02	0.04	0.02	0.02	0.08	0.16	0.09	0.02
3	0.54	0.54	0.53	0.66	0.69	0.23	0.41	0.31	0.31	0.66	0.39	0.73
4	0.64	0.83	0.83	1.15	1.03	0.96	0.70	0.96	0.87	0.77	0.89	1.22
5	0.55	0.95	1.07	1.07	1.10	1.37	1.26	0.87	0.87	1.21	1.16	0.63
6	0.61	0.90	0.89	1.16	1.08	1.05	0.82	0.96	0.89	0.84	1.13	0.93
7	0.61	0.90	0.89	1.16	1.08	1.05	0.82	0.96	0.89	0.84	1.13	0.93

Avg F for ages 2 5 3 5 4 5 5 5

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
2	0.48	0.64	0.64	0.74	0.71	0.65	0.60	0.54	0.53	0.70	0.63	0.65
3	0.58	0.78	0.81	0.96	0.94	0.85	0.79	0.71	0.68	0.88	0.81	0.86
4	0.59	0.89	0.95	1.11	1.07	1.17	0.98	0.91	0.87	0.99	1.03	0.93
5	0.55	0.95	1.07	1.07	1.10	1.37	1.26	0.87	0.87	1.21	1.16	0.63

Avg F (weighted by N) for ages 2 5 3 5 4 5 5 5

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
2	0.37	0.50	0.48	0.46	0.50	0.29	0.28	0.20	0.40	0.69	0.55	0.43
3	0.57	0.66	0.71	0.87	0.78	0.57	0.56	0.53	0.45	0.80	0.89	0.83
4	0.61	0.88	0.87	1.12	1.05	1.03	0.83	0.94	0.87	0.83	1.10	1.09
5	0.55	0.95	1.07	1.07	1.10	1.37	1.26	0.87	0.87	1.21	1.16	0.63

Avg F (wt by catch) for ages 2 5 3 5 4 5 5 5

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
2	0.46	0.60	0.67	0.81	0.78	0.72	0.60	0.60	0.53	0.78	0.90	0.84
3	0.58	0.68	0.74	0.90	0.80	0.80	0.63	0.65	0.55	0.81	0.98	0.86
4	0.61	0.88	0.88	1.12	1.05	1.04	0.87	0.94	0.87	0.84	1.11	1.12
5	0.55	0.95	1.07	1.07	1.10	1.37	1.26	0.87	0.87	1.21	1.16	0.63

BACKCALCULATED PARTIAL RECRUITMENT

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.29	0.22	0.11	0.06	0.02	0.03	0.02	0.02	0.09	0.13	0.07	0.02
3	0.84	0.57	0.50	0.57	0.62	0.17	0.32	0.32	0.34	0.55	0.34	0.60
4	1.00	0.88	0.77	0.99	0.93	0.70	0.55	1.00	0.97	0.64	0.77	1.00
5	0.85	1.00	1.00	0.92	1.00	1.00	1.00	0.90	0.98	1.00	1.00	0.52
6	0.96	0.94	0.83	1.00	0.98	0.76	0.65	1.00	1.00	0.69	0.98	0.76
7	0.96	0.94	0.83	1.00	0.98	0.76	0.65	1.00	1.00	0.69	0.98	0.76

MEAN BIOMASS (MT)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	4999	4514	6316	4010	6047	8133	17713	2828	2584	4214	4324	4190
2	8746	4788	4504	6988	4703	7085	9282	19889	2647	2463	5641	5038
3	5090	7269	3938	3872	5877	4409	6733	9090	18899	2250	2631	3915
4	4981	3186	5021	2490	2355	3870	3358	4609	5463	13782	1495	1346
5	5582	2577	1528	2672	1067	997	1697	2028	2132	2981	5440	897
6	766	2849	1303	621	1014	437	360	416	1363	1267	908	3091
7	4237	1683	1552	1142	901	776	421	707	1519	1079	786	429
1+	34402	26867	24161	21793	21963	25706	39563	39569	34608	28036	21225	18907

Summaries for ages 2 5 3 5 4 5 5 5

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
2	24399	17820	14990	16022	14002	16360	21069	35617	29142	21476	15207	11196
3	15654	13032	10486	9034	9299	9276	11787	15728	26494	19013	9566	6158
4	10563	5764	6548	5162	3422	4867	5054	6638	7595	16763	6935	2243
5	5582	2577	1528	2672	1067	997	1697	2028	2132	2981	5440	897

CATCH BIOMASS (MT)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0	0	0	0	0	0	0	0	0	0	0	0
2	1603	1013	519	514	110	284	203	421	220	390	481	98
3	2746	3955	2093	2555	4027	1007	2737	2831	5835	1483	1027	2847
4	3198	2659	4144	2872	2421	3704	2343	4428	4763	10603	1335	1646
5	3052	2452	1638	2868	1178	1370	2144	1763	1863	3595	6305	569
6	471	2557	1163	722	1095	459	295	402	1220	1061	1030	2869
7	2602	1511	1385	1328	973	815	345	682	1359	904	892	398
1+	13672	14147	10941	10859	9802	7640	8068	10526	15260	18037	11070	8428

Summaries for ages 2 5 3 5 4 5 5 5

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
2	10599	10079	8393	8809	7735	6366	7427	9443	12681	16071	9148	5160
3	8996	9066	7874	8295	7625	6082	7224	9021	12461	15681	8667	5062
4	6250	5111	5782	5740	3598	5075	4487	6191	6626	14198	7640	2214
5	3052	2452	1638	2868	1178	1370	2144	1763	1863	3595	6305	569

SSB AT THE START OF THE SPAWNING SEASON - males & females (MT)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	328	297	399	142	214	292	642	111	221	310	346	336
2	2143	1247	1141	3096	2016	3043	4034	8713	638	591	1137	1083
3	3185	4634	2503	3871	6013	4219	6442	8559	10269	1297	1307	2503
4	4821	3105	4650	2781	2576	4029	3650	5089	5334	12174	1261	1410
5	6070	2972	1738	2983	1205	1184	2018	2189	2290	3059	6755	854
6	823	3496	1429	739	1246	511	409	598	1302	1282	1174	2948
7	5407	2309	2127	1666	1290	1103	566	986	2083	1459	1140	593
1+	22776	18060	13987	15278	14558	14382	17761	26246	22138	20172	13120	9727

The above SSBs by age (a) and year (y) are calculated following the
algorithm used in the NEFSC projection program, i.e.

$$SSB(a,y) = W(a,y) \times P(a,y) \times N(a,y) \times \exp[-Z(a,y)]$$

where $Z(a,y) = 0.1667 \times M(a,y) + 0.1667 \times F(a,y)$
$N(a,y)$ - Jan 1 stock size estimates (males & females)
$P(a,y)$ - proportion mature (generally females)
$W(a,y)$ - weight at age at the beginning of the spawning season

The W(a,y) are assumed to be the same as the Jan1 weight at age estimates
(see "WT AT AGE" table in input section).
Jan1 weights at age are calculated as geometric means in ADAPT
from the mid-year weight at age estimates (from the catch)
of the cohort in successive years.

MEAN STOCK NUMBERS (thousands) - GMCOD94

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	5555	5015	7017	4455	6719	9036	19681	3142	2871	4682	4804	4656
2	7565	4113	3886	5546	3607	5396	7320	15950	2472	2180	3680	3897
3	3059	4379	2358	2217	3199	2618	3579	5118	11170	1435	1369	2072
4	1802	1287	1845	877	806	1179	1384	1540	2406	5486	551	536
5	1170	682	415	598	231	206	328	525	500	721	1777	206
6	114	478	221	112	167	64	53	85	178	173	182	501
7	375	173	152	117	88	75	37	58	111	94	74	39
1+	19640	16128	15895	13923	14817	18575	32383	26419	19707	14772	12437	11906

Time stamp at end of run 1994 11 8 9 59 24

Appendix 3.

Precision estimates of the 1994 age-specific stock sizes, catchability coefficients, and 1993 instantaneous fishing mortality rates (F) and spawning stock biomass (SSB) for Gulf of Maine cod.

ADAPT ESTIMATE is from the final assessment run.

Standard errors, coefficients of variation (C.V.), and bias estimates are derived from 300 bootstrap replications.

F on ages 4+ represents the fully-recruited portion of the stock.

BOOTSTRAP RESULTS FOR GMCOD94 Timestamp 1994 11 8 13 15 25
COD: GULF OF MAINE STOCK

SEED FOR THE RANDOM NUMBER GENERATOR: 74747
MAIN LOOP LIMIT IN MARQUARDT ALGORITHM: 50
NUMBER OF BOOTSTRAP REPLICATIONS ATTEMPTED: 300
NUMBER FOR WHICH NLLS CONVERGED: 300
Results from the converged replications are used for computing the statistics that follow. Other replications are ignored.

Appendix 3:Table 1. BOOTSTRAP OUTPUT VARIABLE: N_hat
Age-specific stock sizes (on Jan 1, 1994) estimated by ADAPT

ADAPT ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR ADAPT SOLN
4.206E3	4.249E3	1.128E3	0.27
3.484E3	3.586E3	7.903E2	0.23
1.258E3	1.269E3	3.365E2	0.27
2.422E2	2.580E2	8.932E1	0.37
1.318E2	1.422E2	5.148E1	0.39

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	ADAPT EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
4.298E1	6.510E1	1.02	4.163E3	0.27
1.014E2	4.563E1	2.91	3.383E3	0.23
1.071E1	1.943E1	0.85	1.247E3	0.27
1.583E1	5.157E0	6.54	2.263E2	0.39
1.034E1	2.972E0	7.84	1.215E2	0.42

Appendix 3:Table 2. BOOTSTRAP OUTPUT VARIABLE: q_unscaled
Catchability estimates (q) for each index of abundance used in the ADAPT run. Note that these q's have been re-scaled to original units.

ADAPT ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR ADAPT SOLN
8.741E-5	8.934E-5	1.415E-5	0.16
1.499E-4	1.492E-4	2.321E-5	0.15
2.351E-4	2.383E-4	3.780E-5	0.16
2.958E-4	2.980E-4	4.573E-5	0.15
2.948E-4	3.006E-4	4.782E-5	0.16
7.191E-5	7.316E-5	1.180E-5	0.16
1.819E-4	1.839E-4	2.843E-5	0.16
3.158E-4	3.205E-4	4.550E-5	0.14
3.505E-4	3.558E-4	5.468E-5	0.16
6.019E-4	5.976E-4	1.045E-4	0.17
2.075E-5	2.074E-5	3.086E-6	0.15
3.255E-5	3.254E-5	5.250E-6	0.16
3.115E-5	3.173E-5	5.597E-6	0.18
3.207E-5	3.232E-5	5.148E-6	0.16
1.350E-3	1.348E-3	2.163E-4	0.16
8.080E-4	8.084E-4	1.289E-4	0.16
4.135E-4	4.178E-4	6.085E-5	0.15
4.320E-4	4.350E-4	6.680E-5	0.15

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	ADAPT EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
1.933E-6	8.169E-7	2.21	8.548E-5	0.17
-7.685E-7	1.340E-6	-0.51	1.507E-4	0.15
3.253E-6	2.183E-6	1.38	2.318E-4	0.16
2.269E-6	2.640E-6	0.77	2.935E-4	0.16
5.850E-6	2.761E-6	1.98	2.889E-4	0.17
1.254E-6	6.813E-7	1.74	7.065E-5	0.17
1.982E-6	1.641E-6	1.09	1.799E-4	0.16
4.770E-6	2.627E-6	1.51	3.110E-4	0.15
5.311E-6	3.157E-6	1.52	3.452E-4	0.16
-4.336E-6	6.035E-6	-0.72	6.063E-4	0.17
-5.810E-9	1.782E-7	-0.03	2.075E-5	0.15
-1.500E-8	3.031E-7	-0.05	3.257E-5	0.16
5.881E-7	3.231E-7	1.89	3.056E-5	0.18
2.535E-7	2.972E-7	0.79	3.182E-5	0.16
-1.306E-6	1.249E-5	-0.10	1.351E-3	0.16
4.434E-7	7.443E-6	0.05	8.075E-4	0.16
4.358E-6	3.513E-6	1.05	4.091E-4	0.15
3.006E-6	3.857E-6	0.70	4.290E-4	0.16

Appendix 3:Table 3. BOOTSTRAP OUTPUT VARIABLE: F_t
Full vector of age-specific terminal F's (in 1993)

ADAPT ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR ADAPT SOLN
2.151E-7	2.284E-7	6.283E-8	0.29
1.954E-2	1.995E-2	4.612E-3	0.24
7.273E-1	7.496E-1	1.408E-1	0.19
1.222E0	1.231E0	2.418E-1	0.20
6.342E-1	6.465E-1	1.820E-1	0.29
9.283E-1	9.386E-1	1.528E-1	0.16
9.283E-1	9.386E-1	1.528E-1	0.16

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	ADAPT EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
1.323E-8	3.627E-9	6.15	2.019E-7	0.31
4.097E-4	2.662E-4	2.10	1.913E-2	0.24
2.224E-2	8.130E-3	3.06	7.051E-1	0.20
8.425E-3	1.396E-2	0.69	1.214E0	0.20
1.226E-2	1.051E-2	1.93	6.219E-1	0.29
1.034E-2	8.822E-3	1.11	9.179E-1	0.17
1.034E-2	8.822E-3	1.11	9.179E-1	0.17

Appendix 3:Table 4. BOOTSTRAP OUTPUT VARIABLE: F_full_t
Fully-recruited F in the terminal year (1993)

ADAPT ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR ADAPT SOLN
9.283E-1	9.386E-1	1.528E-1	0.16

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	ADAPT EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
1.034E-2	8.822E-3	1.11	9.179E-1	0.17

Appendix 3:Table 5. BOOTSTRAP OUTPUT VARIABLE: SSB_spawn_t
SSB (males & females) at start of spawning season (1993)

ADAPT ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR ADAPT SOLN
9.727E3	9.882E3	8.944E2	0.09

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	ADAPT EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
1.544E2	5.164E1	1.59	9.573E3	0.09